AFHRL-TR-88-50

2

AIR FORCE

HUMAN RESOURCES LABORATORY

AD-A209 685

RESEARCH AND DEVELOPMENT OF THE TRAINING DECISIONS SYSTEM

David S. Vaughan
Jimmy L. Mitchell
Robert M. Yadrick
Bruce M. Perrin
J. Ralph Knight
A. John Eschenbrenner, Jr.

McDonnell Douglas Astronautics Company
P.O. Box 516
St. Louis, Missouri 63166

Frederick H. Rueter
Steven I. Feldsott

CONSAD Research Corporation
121 North Highland Avenue
Pittsburgh, Pennsylvania 15206

TRAINING SYSTEMS DIVISION
Brooks Air Force Base, Texas 78235-5601

June 1989
Final Technical Report for Period September 1983 - September 1988

Approved for public release; distribution is unlimited.

AIR FORCE SYSTEMS COMMAND
BROOKS AIR FORCE BASE, TEXAS 78235-5601

NOTICE

This report has been reviewed and is approved for publication.

WINSTON R. BENNETT, Contract Monitor
Training Systems Division

HENDRICK W. RUCK, Technical Advisor
Training Systems Division

HAROLD G. JENSEN, Colonel, USAF
Commander

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution is unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S) AFHRL-TR-88-50
6a. NAME OF PERFORMING ORGANIZATION McDonnell Douglas Astronautics Company PM 6b. OFFICE SYMBOL *(If applicable)*	7a. NAME OF MONITORING ORGANIZATION Training Systems Division
6c. ADDRESS *(City, State, and ZIP Code)* P.O. Box 516 St. Louis, Missouri 63166	7b. ADDRESS *(City, State, and ZIP Code)* Air Force Human Resources Laboratory Brooks Air Force Base, Texas 78235-5601
8a. NAME OF FUNDING/SPONSORING ORGANIZATION Air Force Human Resources Laboratory 8b. OFFICE SYMBOL *(If applicable)* HQ AFHRL	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER F33615-83-C-0028
8c. ADDRESS *(City, State, and ZIP Code)* Brooks Air Force Base, Texas 78235-5601	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. 62703F; PROJECT NO. 7734; TASK NO 12; WORK UNIT ACCESSION NO. 01

11. TITLE *(Include Security Classification)*
Research and Development of the Training Decisions System

12. PERSONAL AUTHOR(S) Vaughan, D.S.; Mitchell, J.L.; Yadrick, R.M.; Perrin, B.M.; Knight, J.R.; Eschenbrenner, Jr., A.J.; Rueter, F.H.; Feldsott, S.I.

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT *(Year, Month, Day)*	15. PAGE COUNT
Final	FROM Sep 83 TO Sep 88	June 1989	74

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS *(Continue on reverse if necessary and identify by block number)*
FIELD	GROUP	SUB-GROUP	alternative utilization ~~and~~ training, Management Information System, career path simulation, modeling, integration optimization, task training module. (JES)
05	09		

19. ABSTRACT *(Continue on reverse if necessary and identify by block number)*

This document summarizes the research and development activities undertaken to develop the Training Decisions System (TDS). The TDS is a computer-based decision aid to be used in planning the what (training content), the where (technical school, Field Training Detachment (FTD), on-the-job training (OJT)), and the when (at what point in an airman's career). Further, the TDS incorporates optimization strategies to allow training managers to ask "what if" questions related to current and possible future policy changes within the Air Force training environment. In addition, this report contains a brief conceptual overview of the three major data-based subsystems and the fourth integrating/optimization subsystem which compose the present TDS. The first subsystem of the TDS is the Task Characteristics Subsystem (TCS). The TCS identifies what tasks are required to be trained and where to allocate those tasks for the most efficient training. The second subsystem of the TDS is the Field Utilization Subsystem (FUS). The FUS has the capability to dynamically simulate the current utilization and training (U&T) pattern job structures and personnel flows for an Air Force specialty. The FUS also simulates

(Continued)

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL Nancy J. Allin, Chief, STINFO Branch	22b. TELEPHONE *(Include Area Code)* (512) 536-3877 — 22c. OFFICE SYMBOL AFHRL/SCV

DD Form 1473, JUN 86 *Previous editions are obsolete.* SECURITY CLASSIFICATION OF THIS PAGE

Unclassified

Item 18 (Concluded):

training allocation
training capacity
training content
training costs
training planning and programming
training resources
utilization and training

Item 19 (Concluded):

logical alternative U&T pattern job structures and personnel flows derived from Subject-Matter Expert (SME) judgments. These simulations are especially important to the determination of the when of the training. Additionally, the FUS gathers information regarding the Air Force manager preferences for the current and the alternative U&T patterns. The third subsystem of the TDS is the Resource/Cost Subsystem (RCS). The RCS identifies training resource capacities and highlights constraints for the provision of training at representative Air Force sites. The RCS also calculates relative direct costs for the provision of training for various training settings at representative sites. The fourth subsystem of the TDS, the Integration/Optimization Subsystem (IOS), provides Air Force decision makers with the capability to optimize training outcomes based upon mathematically derived objective functions. Further, descriptions of the objective data sources and data collection activities which are necessary to inform the decision support functions are provided. Implications from recent trends in Air Force personnel and training policy that affect training management and planning, and a review of agencies within the Air Force which could support and use technologies such as the TDS are discussed. Finally, conclusions and recommendations for using TDS research products in the operational Air Force, including a draft Air Force Regulation for implementing and maintaining the TDS, are presented.

SUMMARY

The Training Decisions System (TDS) is a computer-based decision support technology which has been developed to provide a more integrated approach to Air Force training planning and programming. The present TDS technology has been designed and developed to address the what (training content), the where (classroom, hands-on, self study, and on-the-job training), and the when (at what point in an airman's career) of specialty training. The TDS identifies specialty jobs and training programs in terms of groups of related tasks (Task Training Modules), examines the allocation of task modules to various training settings, and estimates training capacities and costs for representative organizational units. Further, the TDS incorporates modeling strategies to allow functional or training managers to conceptualize present utilization and training patterns and to ask "what if" questions involving possible future policy changes within the Air Force functional and training environments. Such policy alternatives can be evaluated by Air Force decision makers in terms of their relative costs and constraints on specialty training which can be identified for all training settings. The present TDS technology consists of three major data-based subsystems and a fourth integration and optimization subsystem, with supporting software. This report provides a brief overview of the TDS research program conducted on four Air Force specialties (AFSs): Electronic Computer and Switching Systems (AFS 305X4), Avionic Inertial and Radar Navigation Systems (AFS 328X4), Aircraft Environmental Systems (AFS 423X1), and Security Police/Law Enforcement (AFS 811XX). In addition, a summary of the objective data sources and data collection activities which are needed to form the decision support functions is provided. The report also examines issues which arose during the course of this project in terms of recent trends in Air Force personnel and training policy that affect training planning. Finally, the report discusses recommendations for future training decisions technology research and development and for using TDS research outcomes in the operational Air Force.

PREFACE

The Training Decisions System (TDS) is a multi-year exploratory research and development effort by the Air Force Human Resources Laboratory sponsored by HQ USAF and HQ ATC. The goal of this effort is to develop a proof-of-concept, computer-based decision support technology for a more integrated approach to Air Force training planning and programming.

The initial TDS has been developed for the United States Air Force under Contract Number F33615-83-C-0028. This initial proof-of-concept effort was accomplished by the Human Factors section of the Systems Engineering and Analysis Department, McDonnell Douglas Astronautics Company, St. Louis, Missouri, and CONSAD Research Corporation, Pittsburgh, Pennsylvania. In the initial phases of the work, the Research Triangle Institute, Research Triangle Park, North Carolina, assisted in the project. In the final phase of the TDS project, the Manpower, Personnel, Training, and Research Division of the MAXIMA Corporation, San Antonio, Texas, assisted in the sensitivity analyses.

This volume is the final report of the initial exploratory research and development effort and, as such, provides a general overview of the design work performed to develop the proof-of-concept TDS. Details of each phase of the effort can be found in the TDS reports noted below:

Vaughan, D.S., Yadrick, R.M., Perrin, B.M., Cooley, P.C., Dunteman, G.H., Clark, B.L., & Rueter, F.H. (1984, August). Training decisions system preliminary design. Unpublished manuscript.

Vaughan, D.S., Yadrick, R.M., Perrin, B.M., Mitchell, J.L., Sturdevant, W.S., Rueter, F.H., & Ward, J., Jr. (1985, September). Training decisions system transition plan. Unpublished manuscript.

Perrin, B.M., Knight, J.R., Mitchell, J.L., Vaughan, D.S., & Yadrick, R.M. (1988, September). Training decisions system: Development of the task characteristics subsystem (AFHRL-TR-88-15, AD-A199 094). Brooks AFB, TX: Training Systems Division, Air Force Human Resources Laboratory.

Yadrick, R.M., Knight, J.R., Mitchell, J.L., Vaughan, D.S., & Perrin, B.M. (1988, July). Training decisions system: Development of the field utilization subsystem (AFHRL-TR-88-7, AD-A198 087). Brooks AFB, TX: Training Systems Division, Air Force Human Resources Laboratory.

Rueter, F.H., Feldsott, S.I., & Vaughan, D.S. (1989). Training decisions system: Development of the resource cost subsystem (AFHRL-TR-88-52). Brooks AFB, TX: Training Systems Division, Air Force Human Resources Laboratory.

Vaughan, D.S., Mitchell, J.L., Marshall, G.A., Feldsott, S.I., & Rueter, F.H. (1988, August). Training decisions system procedural guide: TDS user instructions. Unpublished manuscript.

ACKNOWLEDGEMENTS

A number of organizations and individuals provided assistance in the various phases of the TDS research and development effort; too many to all be individually recognized here. We greatly appreciate the assistance of all who helped; there are, however, some who we particularly wish to acknowledge here for their contributions in helping make the TDS a success.

Dr Joe H. Ward, Jr., consultant with CONSAD Research (now a counsultant with Metrica, Inc.), San Antonio, TX
Dr S. Craig Moore, Advanced Technology, Inc. (now with the RAND Corp., Santa Monica, CA)
Dr Hendrick W. Ruck, now Technical Advisor, AFHRL Training Systems Division, Brooks AFB, TX
Mr William J. Phalen, CODAP Manager, AFHRL Manpower and Personnel Division, Brooks AFB, TX
Mr Curtis Yelverton, Cost Analysis Directorate, HQ ATC/ACC, Randolph AFB, TX
Mr Cordell Smithfield, HQ ATC/ACC (now at TPDC, Orlando, FL)
Mr Wayne B. Archer, Program Manager, AFHRL Manpower and Personnel Division, Brooks AFB, TX
Mr Ed Boyle, SUMMA Manager, AFHRL Logistics Research Division, Wright-Patterson AFB, OH
SMSgt Thadous J. Magwood, Training Division, Air Force Office of Security Police, Kirtland AFB, NM
LtCol Dick Harris (now retired), HQ USAF/MPPTS, the Pentagon
CMSgt Donald J. Averett, Comm-Electronics, HQ USAF/LEYE, the Pentagon, VA
CMSgt Dan Marvin, Airmen Assignments, Air Force Military Personnel Center, Randolph AFB, TX
SMSgt John Fenslage, USAF Retired, Subject-Matter Expert, Ft. Worth, TX.
Capt Tracey Horton & Maj Bill Cummings, Research Plans, HQ ATC/XPC, Randolph AFB, TX
Mr Don Hickman (now retired), HQ ATC/TTQL, Randolph AFB, TX
Dr Burke Burright, Plans Officer, AFHRL/SA, Brooks AFB, TX
Capt Ed Harron, Capt Goslin, and MSgt Bill Cole, Security Police Training Staff Officers, HQ ATC/TTQ, Randolph AFB, TX
Col Doran, Commander, and members of the 3280th Technical Training Group, Lackland AFB, TX
Col Ron Baker, Commander, & members of the USAF Occupational Measurement Center, Randolph AFB, TX
Col Paul Ringenbach (now retired), former USAFOMC Commander
Maj Jack Blackhurst & members of AFHRL/OL-AK, Bergstrom AFB, TX
Mr Bill Haynes, Programmer, Consultant for CONSAD Research (now with Metrica Inc.), San Antonio, TX
Mr Winston R. Bennett, TDS Manager, AFHRL Training Systems Division, Brooks AFB, TX

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

List of Figures (Concluded)

LIST OF TABLES

RESEARCH AND DEVELOPMENT OF THE TRAINING DECISIONS SYSTEM

1. INTRODUCTION

The Training Decisions System (TDS) is designed to assist Air Force managers in making critical judgments concerning the what, when, and where of training required for an Air Force specialty (AFS) by providing models which characterize the current and several alternative Utilization and Training patterns, and methods for evaluating these models. Using the TDS, Air Force managers can assess the relative impact of each proposed alternative in terms of relevant costs and resource requirements, including the costs of on-the-job training (OJT). The TDS can help specialty managers formulate optimal (cost effective) manpower, personnel, and training (MPT) policies for the specialty.

1.1 Technical Approach

The TDS was a proof-of-concept project; the initial phase of the effort involved the collection and analysis of information concerning present Air Force training decision making. The types of data needed by Air Force managers were identified as well as ways to collect or develop information not previously readily available to decision makers. A top-down structured analysis approach was then used to design system components to identify groups of tasks which could be trained together; to model the specialty in terms of jobs and training requirements; and to collect, analyze, or predict needed data and functions. The TDS design included integration of components into an overall system which could display data to properly assist Air Force decision makers. Software was developed for the TDS to operate on the AFHRL UNISYS 1100 Computer.

1.2 Innovations

The TDS project required the development of innovative new approaches for modeling the dynamics of military occupations and assessing job training requirements. Allocation curves were developed to relate hours of training in different settings (such as classroom, hands-on, self study, and OJT) to the degree of proficiency which can be achieved for groups of related job tasks. The specialty modeling approach was integrated with state-of-the-art econometric techniques to estimate total training capacities and costs in different training settings, including OJT. The TDS was designed to make maximum possible use of existing data bases; it also required development of data collection methodologies and creation of new techniques to estimate job and training assignment probabilities at various career stages. Computer programs were created to simulate the complex flows of people through jobs and training programs.

1.3 Applications of the TDS

The TDS was developed for use by members of the Air Staff to support the Planning, Programming, and Budgeting System (PPBS); functional

managers and major command (MAJCOM) training staffs to evaluate proposals for changing specialty structure or training programs; Training Planning Teams (TPTs) in managing major changes in AFS training (AFR 50-8); and Utilization and Training Workshops (U & TWs) convened by the Air Training Command (HQ ATC) to plan implementation of training changes. HQ ATC and its subordinate units responsible for Instructional Systems Development (ISD) can make use of the system for identifying Air Force specialty training requirements ("front end analysis") and to assess the cost of proposed changes in training.

Other Manpower, Personnel, and Training (MPT) agencies, such as the Air Force Military Personnel Center (AFMPC), Air Force Management Engineering Agency (AFMEA), and the USAF Occupational Measurement Center (USAFOMC) can use the TDS to assess the impact of proposed AFS changes or the reengineering of jobs. The MPT research community could employ the TDS to secure needed AFS-specific data, such as training requirements or costs, or may use the system as a foundation for studying MPT integration.

1.4 Organization of Report

This final technical report summarizes the work done on the system, provides an overview of the system developed, notes problem areas, suggests areas for further research, and provides recommendations for the operational implementation of the system. The report is organized as follows.

Chapter 2 provides a conceptual overview of the TDS developed in this research and development (R&D) project. The background of the project is discussed, along with the recent trends in Air Force training decision making and previous AFHRL programs which have led to the present line of research. The complex requirements for various types of objective data for use in Air Force training decision making are discussed, and how such needs were met in the design of TDS subsystems are noted. References are provided for those interested in more detail on the system or the various phases of its development.

Chapter 3 briefly reviews the agencies which might make use of the TDS and the various ways in which the system can be employed. Ways in which users can interface with the present prototype system are outlined, as well as suggestions for how such user interface should be implemented in an operational system.

Chapter 4 notes some of the issues raised and problems encountered in conducting the project. Specific subsystem issues are outlined and recommendations made for future R&D work to resolve these issues.

Chapter 5 discusses several conceptual issues in current Air Force training decision processes and recommends ways in which these might be resolved. The implementation of TDS as an operational system is recommended along with parallel R&D efforts to cross-validate the system with studies of additional specialties and develop enhancements to be incorporated into the system. Suggestions for specific Air Force organizational responsibilities to implement the system are outlined in a proposed Air Force Regulation (see Appendix A).

2. A CONCEPTUAL OVERVIEW

For nearly two decades, the Air Force has been using the Instructional Systems Development (ISD) model to guide the design of technical training for enlisted occupations and for support of new weapon system acquisition (see AFR 50-8). The ISD model requires a systems approach to training development, an approach aimed at providing "optimal training" for each specialty or weapon system (AFM 50-2, AFP 50-58). Many of the data elements required for the application of ISD, however, are not readily available in existing Air Force data bases. Further, not all decision algorithms suggested in the ISD model have been empirically validated nor are such algorithms equally applicable to all types of specialties. Decisions involving aircraft maintenance specialties, for example, may require an approach to training decision making that addresses issues which have a direct and immediate impact on combat sortie generation, whereas for a support specialty, the issues may involve primarily the cost per student or student flow limitations.

Recent developments in occupational analysis and training research, as well as in Air Force decision making processes (see AFR 50-8), have created new opportunities for optimizing training. Such developments include the recent emergence of Utilization and Training Workshops (U & TWs) and Training Planning Teams (TPTs) as the primary vehicles for making major training decisions. Such innovative procedural changes also make obvious a need for a technologically advanced data generation, analysis, and evaluation capability. To make good decisions about the training needed for an Air Force specialty or system, decision makers must be able to visualize and understand the jobs and training programs of the specialty or weapon system under consideration and its technical training and Professional Military Education (PME) requirements, as well as the relative costs and payoffs of various training options. Such a "model" provides a concise summary of the current status of the specialty, creates a common "language" for discussion or negotiation, and forms the baseline against which various alternative proposals can be evaluated.

To provide adequate support for such advanced training decision making, the Air Force Deputy Chief of Staff for Personnel, Education and Training (HQ USAF/DPPE) requested that the Air Force Human Resources Laboratory develop a computer-based Training Decisions System (TDS) to augment the Air Force ISD model. Such a system would generate necessary front-end training requirements data, validated decision algorithms, and procedures for improved interaction among training, personnel, and functional managers. The TDS would focus on supporting Air Force managers in making decisions as to the <u>what</u>, <u>where</u>, and <u>when</u> of the training (including the On-the-Job Training) required for a given enlisted specialty (Ruck, 1982).

2.1 Background

Over several decades, the Air Force has evolved a task-based approach to determining technical training content and reviewing personnel classification and utilization policies (Christal, 1974; Mitchell, 1988; Morsh, 1964; also see AFR 8-13). As part of the occupational analysis

(OA) process, tasks are defined by subject-matter experts (SMEs) of a specialty in their own technical terminology, working with analysts of the USAF Occupational Measurement Center, Randolph Air Force Base, Texas (see AFR 35-2). Several kinds of data on these tasks are collected from job incumbents and supervisors for use in reviewing training programs (see ATCR 52-22). Large samples of incumbents are asked to provide information about which tasks they perform in their present jobs and the relative amount of their job time spent performing such tasks. These data are used to examine the variety of specialized jobs within a specialty (occupation), to assess how jobs change at advanced skill levels, and to review official specialty descriptions and initial training programs (Christal & Weissmuller, 1988; Mitchell, Ruck, & Driskill, 1988).

One of the most important data elements developed during the OA process involves noncommissioned officer (NCO) ratings of tasks in terms of recommended training emphasis for first-term and first-job airmen. Such training emphasis (TE) ratings have been validated empirically using explanatory regression models in studies of 18 AFSs (Ruck, Thompson, & Stacy, 1987; Ruck, Thompson, & Thomson, 1978; Stacy, Thompson, & Thomson, 1977) Two important findings of these research studies were that supervisors agreed substantially with one another on their recommendations in most (but not all) career fields, and that supervisors' judgments were explainable in terms of key ISD factors. A third important finding was that supervisors could not agree as to the appropriate sites for training technical tasks. TE ratings are used operationally to evaluate course content of basic technical training courses for first enlistment or first job personnel; typically they are not used to evaluate field training detachment (FTD) or mobile training team (MTT) courses or OJT programs (Mitchell, Ruck, & Driskill, 1988; Mitchell, Sturdevant, Vaughan, & Rueter, 1987; see also ATCR 52-22). Hence, although methods had been developed and validated for prioritizing AFS job tasks in terms of recommended training emphasis for first enlistment personnel, no reliable data were yet available for determining appropriate training setting and site.

By 1980, the determination of training setting was being made at U & TWs, where trainers and training managers met with representatives from operational commands to negotiate training content and training setting (Mitchell et al., 1987; see also ATCR 52-15). These conferences grew out of earlier procedures developed to bring initial skills technical training in line with initial job requirements ("HASTY GRAD" projects), while at the same time planning for those training requirements deferred to FTD, MTT or OJT (Ruck & Birdlebough, 1977; Vaughan, 1978). Only minimal data were available for determining appropriate training settings for specialty tasks; thus, these decisions were, of necessity, based almost entirely upon the conferees' personal experience, or on known constraints at the resident training school. For these reasons, many of the decisions made in U & TWs cannot be consistently replicated. In addition, no formal evaluation or estimates were made of the impact of such decisions on personnel utilization, OJT costs, or mission performance (Ruck, 1982).

2.2 Approach

The general strategy used in developing the Training Decisions System focused on first defining functional requirements and then developing the

structure, methodologies, and procedures for meeting those requirements. The research team collected as much information as possible concerning Air Force training decisions and how they were made; a variety of agencies and offices were visited to define the desired functions and data requirements of the system (Mitchell, Sturdevant, Vaughan, & Rueter, 1987).

Based on the information gathered from such visits and a review of the previous research literature, the following types of variables were determined to be particularly important for Air Force decision makers and thus must be represented explicitly within the TDS:

- Tasks of the Specialty and Their Associated Characteristics
- Task Allocations to Training Settings
- Managers' Preferences for Task Allocations to Training Settings
- Times Required to Train Tasks in Various Setting Allocations
- Utilization and Training Patterns, in terms of:
  - Jobs and Associated Tasks
  - Training States
  - Transition Probabilities Among Jobs and Training States
  - Numbers of Airmen in Various Training and Job States
  - Airman Proficiency States
- Training Costs
- Training Resource Requirements
- Training Capacities
- Managers' Preferences for U & T Patterns

Some data on the tasks, jobs, and training states are generally available from existing sources, such as the occupational analysis program or course documentation. For other variables, few if any data are available in existing Air Force data bases. For example, data concerning OJT costs are not routinely available, and innovative approaches were required to develop such information for use by training decision makers.

A preliminary integrated systems design was developed to guide the R&D effort which provided for a set of interactive subsystems to deal with the three broad classes of data (task information, training and job patterns, and costs versus training capacity constraints) plus a fourth subsystem to integrate such data and display the data for decision makers. The preliminary system design was validated and refined through interactions with potential Air Force users (Vaughan, Yadrick, Perrin, Cooley, Dunteman, Clark, & Rueter, 1984).

The general approach used in TDS development was to start from known data bases, such as the OA report files or personnel flow statistics, and to develop new data gathering technologies to determine, estimate, or approximate other required information. Where possible, an evaluation of alternative approaches was conducted; several methods were initially tested and the method yielding the best results was adopted for use in the

TDS. Where necessary, experimental designs were employed when it was necessary to verify method effects or analyze data differences. Generally, data collection and analysis methods were developed on two Air Force specialties (Avionic Inertial and Radar Navigation Systems, AFS 328X4, and Security and Law Enforcement, AFS 811XX), and were later validated and refined on two additional specialties (Electronic Computer and Switching Systems, AFS 304X4, and Aircraft Environmental Systems, AFS 423X1).

Such development and testing was done in a systematic, integrated way to ensure that the various types of information could be synthesized into a coherent picture of the various ways training requirements of a specialty could be met and the relative cost of each alternative. The objective was to make visible to specialty managers and training staff officers their decision options, as well as the constraints and relative cost consequences of each decision.

At periodic intervals throughout the TDS development project, the research and development team briefed their progress and results to an Air Force TDS advisory panel, which included representatives of HQ USAF, HQ Air Training Command, the USAF Occupational Measurement Center, functional specialty managers, and training managers. Such periodic progress reviews were extremely constructive in terms of constructive critique of results and positive interaction between researchers and potential system users. Suggestions were made for needed design improvements, data displays, new data sources to be evaluated, or other possible solutions to research and development problems. As a result of such interactions, a separate plan was developed to guide the transition of TDS from a research and development project to an operational system in an appropriate Air Force organization; this transition plan was circulated to various Air Force agencies and offices for coordination and staffing (Vaughan, Yadrick, Perrin, Mitchell, Sturdevant, Rueter, & Ward, 1985). The end result of such interactive progress reviews was an improved systems design and TDS products which should be much more useful to potential TDS users.

2.3 Results - The Proof-of-Concept Training Decisions System

The initial research and development of the TDS has been completed. The proof-of-concept system consists of three interdependent subsystems which deal with Task Characteristics, Field Utilization pattern modeling, and Cost/Resource data generation, as well as a fourth Integration and Optimization subsystem (see Figure 1). This section of the report will present a conceptual overview of the system to provide a general perspective of the TDS and a basic understanding of its structure and operation. For the purposes of the present report, a short description of each subsystem and how it was developed should suffice.

[For the details of the preliminary design, see Vaughan, Yadrick, Perrin, Cooley, Dunteman, Clark, & Rueter, 1984; for the proposed transition plan, see Vaughan, Yadrick, Perrin, Mitchell, Sturdevant, Rueter, & Ward, 1985. For details of the development of each subsystem, see the subsystem technical reports cited in the text below and listed in the Reference section.]

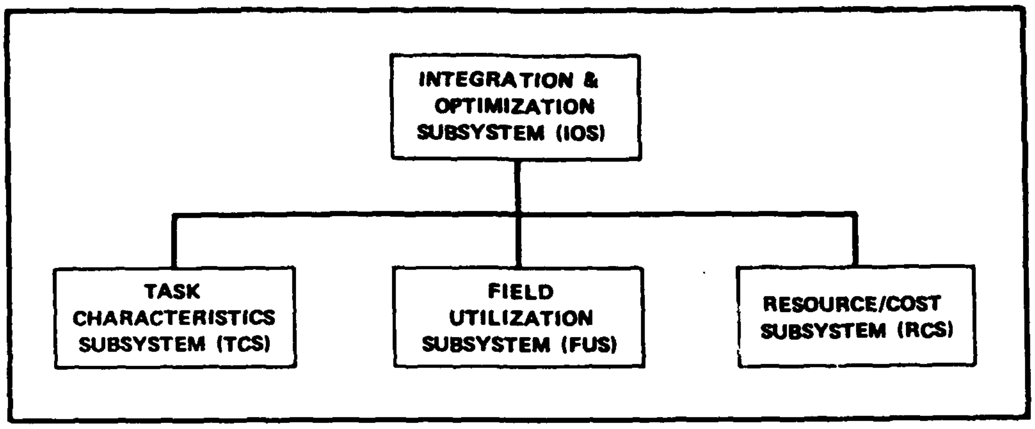

Figure 1. Major Subsystems of the Training Decisions System.

2.3.1 Task Characteristics Subsystem (TCS)

The TCS is composed of two components. The Task Training Module (TTM) construction component is designed to generate TTMs as the basic unit of analysis in the TDS. TTMs solve a number of problems associated with the use of task-level data (see Perrin, Knight, Mitchell, Vaughan, & Yadrick, 1987). As noted earlier, the Air Force presently makes some use of task-based data for training decisions; one problem is that many tasks share a common skill and knowledge base. TTM-level data reflect shared skills and knowledges, thus reducing the possibility of overestimating training requirements. A second problem in using task data is the fact that each specialty involves 300 to 2,000+ tasks, far too many for managers to process in a typical U & TW session. Indeed, U & TW participants generally focus on review of the relevant Specialty Training Standard, leaving detailed review of tasks to occupational analysts and training developers.

According to some interpretations of the ISD literature, in order to fully understand and classify all the tasks of a specialty in terms of their common skills and knowledges, a detailed task analysis would be required on every task before any decisions about training could be made. The fact is that task analysis is an exceedingly time-consuming, labor-intensive, expensive process, and various types of tasks may require differing types of analysis (DeVries, Eschenbrenner, & Ruck, 1980; Eschenbrenner, DeVries, Miller, & Ruck, 1980). The Air Force probably cannot afford the manpower and expense of a detailed task analysis for every task of every specialty.

Therefore, a procedure is needed to group or cluster tasks which share common skills and knowledges; i.e., those tasks which could be trained together most efficiently. In the TDS, individual tasks are grouped into clusters of related tasks called Task Training Modules (TTMs).

2.3.1.1 TTM Construction Component: Judgmental Versus Statistical Clusters. Two approaches to the problem of constructing TTMs were evaluated empirically in the TDS R&D effort (Perrin, Vaughan, Yadrick, Mitchell, & Knight, 1986). One was a judgmental approach, using the expertise of SMEs; a second approach used data from the most recent occupational survey to cluster tasks statistically. In the judgmental approach, SMEs were asked to sort the tasks of their specialty into subjective categories; i.e., to group those tasks which should be trained together. Presumably, the resulting task groupings would: (a) contain tasks which shared similar underlying skills or knowledges, and (b) include tasks performed in the same job. It is a "given" that the same task might appear in more than one job. Results from the attempts to apply this judgmental approach in the initial two specialties (Avionic Inertial & Radar Navigation Systems, AFS 328X4 and Security & Law Enforcement, AFS 811XX) were not encouraging, since each group of SMEs tended to use unique conceptual approaches depending on their backgrounds and present assignment. Even though a fair consensus was achieved through extended negotiation, a complete consensus was not attained. Attempts to refine the clusters with new reviewers resulted in only minor modifications based on their unique perspectives of their specialty.

In the second approach, multivariate statistical techniques were employed in an iterative manner with a variety of input data, such as the probability of co-performance of tasks calculated from available occupational survey report (OSR) data, common equipment usage, and skill-level or grade information. Initial trials indicated that the latter variables added little or no refinement to statistical clusters formed using only a measure of task co-performance. Advanced work focused on use of Comprehensive Occupational Data Analysis Programs (CODAP) hierarchical clustering of tasks and interpretation of meaningful clusters of tasks as TTMs. It was found that the help of SMEs was critical to naming the modules, assessing their significance, and allocating isolated tasks which did not statistically cluster. Thus, the final recommended procedure was a combined approach that utilized statistical co-performance clustering to form initial groupings of tasks, having an analyst identify task groupings which appeared meaningful, and then having SMEs title and refine the task groupings into TTMs. This approach saves time for both analysts and SMEs and provides a structured focus for their efforts. Detailed task analysis of the tasks of a sample of TTMs for two specialties indicated the tasks in TTMs formed through this process did indeed share common skill and knowledge requirements (Perrin et al., 1986).

2.3.1.2 Training Setting Allocation Component. Once TTMs are finalized, survey instruments are developed with which to gather information as to how TTMs are and should be allocated to various training settings. Groups of senior technicians in the specialty, who are thoroughly familiar with the work of the specialty, estimate how much training time is currently devoted to reach minimum required proficiency for the various groups of tasks for the following training settings: classroom, correspondence courses such as career development courses

(CDCs), hands-on training (FTDs, MTTs, etc.), supervised hands-on experience on the job (OJT), and other programs. These raters are also asked to provide training time estimates for "ideal" training (i.e., the most effective mix of types of training). Finally, the raters are asked how long it would take in each setting to train the TTM, if the training was provided in only that setting (e.g., only classroom training, only correspondence course training). This "maximum effective training" may not always yield full proficiency; it may not be possible to fully train a TTM in one or more of the settings alone. In these cases, the respondents indicated the proficiency level reached in each setting as a percent of full proficiency. Thus, each SME provided six allocation judgments for each TTM: four that related the maximum training time in each of four settings to the proficiency level reached, one for the current allocation, and one for the most preferred allocation of training.

Difficult issues such as proficiency measurement and the description of partial allocations of training to different training settings were generally resolved to the satisfaction of the many SMEs who were involved in the development of these procedures.

<u>What Is Proficiency?</u> For TDS, proficiency was defined as a percentage of the training needed by an average individual to reach the minimum required standard for each TTM (the "go/no go" level of OJT = 100% proficiency). SMEs generally understood and were able to estimate degrees of proficiency expressed in this way. SMEs are also able to reliably and consistently describe the current training pattern in terms of how training in each type of setting contributes incrementally to the attainment of full proficiency (i.e., the partial proficiency achieved). They also easily conceptualized other combinations of training for reaching the same goal (i.e., alternative training allocations).

<u>Allocation Functions?</u> It was hypothesized that proficiency gain from training in a setting would be greatest initially and would decline as more training was provided in that setting. Eventually, there would be no more gain from providing training. Thus, the predicted relationship between proficiency and time in a training setting is that of initial gain followed by proficiency leveling-off, a negatively accelerated curve. This general set of relationships is depicted in Figure 2; these curves are theoretical estimates which illustrate the expected form of the relationship.

This relationship can also be expressed in the following polynomial regression equation:

```
Proficiency  =  a * class-hours  -  b * class-hours**2  +
       c * self-study-hours  -  d * self-study-hours**2  +
       e * field-training-hours  - f * field-training-hours**2  +
       g * work-hours  -  h * work-hours**2,
```

where "a" through "h" are coefficients to be estimated by multiple regression, **2 indicates squaring, and the regression equation is constrained to pass through the origin (there is no constant for the Y intercept).

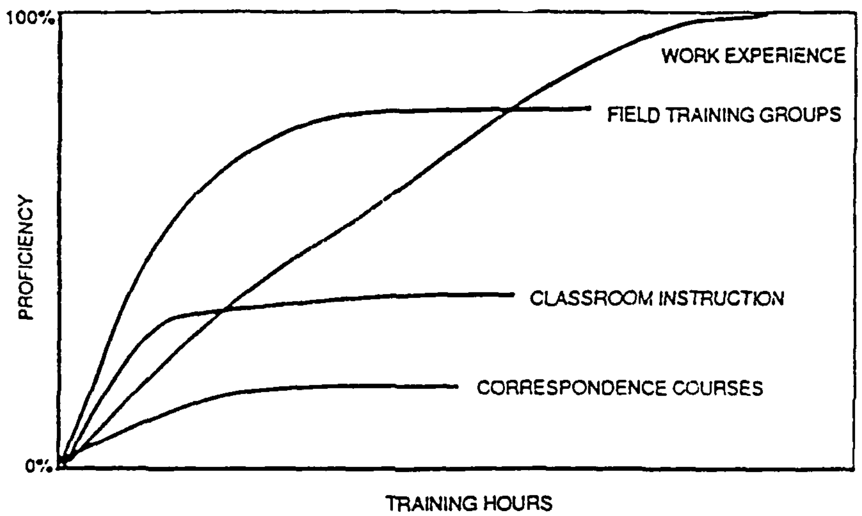

Figure 2. Hypothesized Relationship Between Hours of Training in a Setting and Proficiency Gain (from Perrin et al., 1988, p. 29).

This model involves specific hypotheses about the nature of the relationship between setting training hours and proficiency. Specifically, controlling for training in each of the other training settings, the first-order parameter is specified to be positive and the second-order parameter is negative, yielding the predicted negatively accelerated curve. Across the four AFSs studied during TDS development, this statistical model was strongly supported. Statistical estimates consistent with the polynomial regression equation were found in well over 90% of the allocation curves in all four specialties (Perrin et al., 1988).

There are two additional sources of support for the conceptualization of proficiency gain as a negatively accelerated function of training time in a setting. First, the overall fit of the polynomial regression model was found to be quite good, averaging over 65% (multiple R squared) in two specialties. Second, the additional variance explained by the second-order terms in the allocation equations was substantial (approximately 15% increase in R squared for these two specialties), indicating that simple linear functions are not sufficient to describe proficiency gains from training in each setting (see Figure 3 for an example allocation curve). A curvilinear model is much more descriptive of these relationships (Perrin et al., 1988).

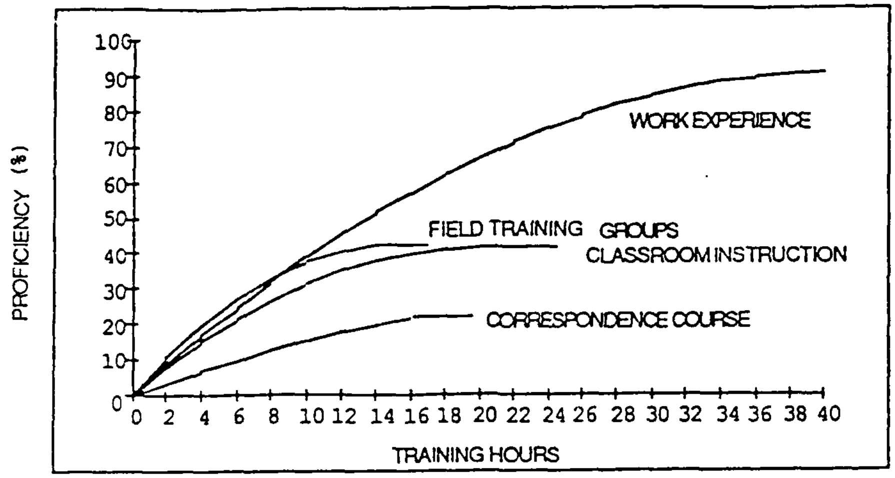

Figure 3. Example Allocation Curves for Aircraft Environmental Systems (AFS 423X1) TTM 34, Doppler Sensor Control Boxes.

Possible alternative allocations range (theoretically) from training everything about a TTM in the classroom to training the TTM entirely on the job. By collecting data from SMEs on a few possibilities (i.e., current, "ideal," and "maximum effective" training) and on the time involved for each, allocation curves are generated which represent all possible combinations. Such curves permit a direct translation among settings of training time to percent of required proficiency for each TTM, thus facilitating specification and evaluation of training alternatives (i.e., various combinations of training times in different settings that, in total, achieve 100% of the required proficiency).

Allocation curves for all TTMs of a specialty derived through this survey approach give the TDS maximum flexibility in considering different ways of dividing training among training settings, as well as identifying the limits of each type of training. This capability serves as the foundation for developing and evaluating alternative patterns of training (as will be discussed in the Field Utilization Subsystem section). Thus, the allocation curves are a very significant part of the overall TDS design; their development and validation represent a substantial advance in training decisions technology.

2.3.1.3 Relationship of the TCS to Other Subsystems. The set of TTMs developed and validated for a specialty represents one of the major building blocks for the TDS. The TTMs are a major input to the FUS and serve as descriptors for jobs and training states (courses, OJT programs, etc.). Data are summarized or averaged to the module (TTM) level, such that jobs can be described in terms of percent of job incumbents performing each TTM and the total time spent on TTMs. Training course content is also expressed in terms of hours of training per TTM. Thus, training and job content share a common set of terms. The TTMs also serve as a foundation for the RCS in that information about training resources required and resource availability are collected on a TTM-by-TTM basis. This greatly reduces the complexity of RCS analyses.

Training allocation curves play an important input in the FUS in terms of facilitating development and evaluation of alternative U & T patterns. These curves make possible the calculation of OJT requirements for each U & T pattern simulation. Allocation curves are also critical to the Resource/Cost Subsystem where they are used for calculating training costs.

2.3.2 Field Utilization Subsystem (FUS)

The FUS provides information for defining training and job assignment patterns with associated management preference values for both current and several plausible alternative approaches to training, assigning, and utilizing airmen in a particular specialty over the span of their Air Force careers (see Yadrick, Knight, Mitchell, Vaughan, & Perrin, 1987). Both training content and job descriptions are represented as collections or sets of TTMs.

2.3.2.1 Current Utilization and Training (U & T) Pattern Component. A description of the current U & T pattern for a given specialty is a necessary starting point both for understanding the current situation and for developing possible management choices. Appropriate data must be synthesized from a variety of sources--most notably from occupational survey (OS) data, the Uniform Airman Record (UAR), the Pipeline Management System (PMS), AFR 50-5, TDS surveys, and informal interaction with functional managers, training managers, and field representatives--to gain a complete picture of the present AFS training and personnel assignment flows. Such information must be summarized and displayed to Air Force managers in a simple, effective format that provides a brief yet comprehensive picture of the specialty.

A key element in defining a career pattern is the identification of the jobs within a specialty. A job is a group of related positions in which many of the same tasks are performed; a position is a unique set of tasks performed by one person (Shartle, 1959; see also AFR 35-2, para. 1). Each AFS includes a number of jobs that vary in content (tasks performed) according to the organizational level, unit mission, equipment operated or maintained, level of experience of personnel, and a number of other interrelated factors (Driskill & Mitchell, 1979).

In previous Air Force R&D, methods were devised for the analysis of OS data collected from job incumbents to identify the major types of jobs which exist in an occupational area (Archer, 1966; Christal, 1974; Driskill & Mitchell, 1979; Morsh, 1964; Ward, 1963). Such information is used to

evaluate the way in which the specialty is organized and the appropriateness of providing initial skills training for various specialty tasks (AFR 35-2; ATCR 52-22; see also Ruck et al., 1978, 1987). In addition, such data have been experimentally processed for identifying tasks for OJT (Datko, Cassidy, & Ruck, 1982), for defining safety priorities (Thompson & Ruck, 1984), and for other advanced uses.

For the TDS, job types were identified using standard occupational analysis (OA) methods. Using two test specialties, several attempts were made to create job clusters based on type of weapon system or equipment maintained, on average grade of personnel performing tasks, and on other potentially relevant factors for two test specialties. Such statistical weighting procedures did not significantly change the jobs identified in the original OA job typing (Yadrick et al., 1987). Cross-KPATH analysis was attempted with three specialties where more than one occupational survey report (OSR) was available, without significant results. In addition, first enlistment jobs (1 to 48 months Total Active Federal Military Service or TAFMS) were contrasted with career (49+ TAFMS) jobs; however, no major differences, other than the expected amount of supervisory-type work, were identified. Thus, the OA job types appear to be a realistic foundation for describing the current U & T pattern for Air Force enlisted specialties (Yadrick et al., 1987). [NOTE: Advanced job typing procedures are currently being developed and tested (Phalen, Staley, & Mitchell, 1987) in an effort to make the process more efficient.]

For TDS, OSR data are reprocessed to create more concise job descriptions based on the TTMs of the specialty from the TCS. The CODAP set of MODULE programs (Module Title File, MODSET, PRTMOD) is used to create a new data base. Four indices are used to characterize the Job-TTM association:

1. the sum, across people and tasks, of the percent time spent performing the tasks of a TTM;
2. a running cumulation of this summed percent time spent index;
3. the average percent time spent per task in the TTM; and
4. the average percent members performing across TTM tasks.

The cumulative sum of percent time spent per module (TTM) was the only index not already computed in ASCII CODAP. Through coordination with AFHRL's Manpower and Personnel Division, this function was added to ASCII-CODAP MODULE programs, thus avoiding any need to write TDS-specific software for this part of the FUS (Yadrick et al., 1987).

The identification of all training courses and job assignment flows within a specialty proved to be a greater problem. For example, not all courses (i.e., FTD and MTT courses) are identified in the typical OSR. AFR 50-5 lists specialty-specific and aircraft-specific courses but does not provide detailed information on course content. Personnel data files (UAR) contain very limited training information but do indicate PME courses attended. They also give assignment histories, but these often use the specialty title or generic skill-level names rather than job titles equivalent to OSR jobs. The PMS contains training attendance and completion records for formal courses by individual, but not by specialty. No existing source could provide all of the data needed.

For TDS purposes, such information was synthesized from various sources to identify specialty courses, relevant generic FTDs, PME programs, and specialized training mechanisms, such as the Educational Subject Block Indices (ESBIs) used in Security Police. A Job and Training History survey was sent to a representative sample of experienced job incumbents (and a random sample of first-job personnel). Respondents identified their present and previous jobs, and listed dates of attendance for all training programs; they could also write in additional training programs. These data were sorted and processed to estimate rates of attendance for the relevant courses for each job, attrition rates, and assignment flows (average length of assignment, PME course attendance points, etc.). Such information was compared to the OSR or data from other objective sources.

Graphic flow patterns were developed (see example in Figure 4), as well as concise summaries of the data. Such displays were validated with specialty SMEs in subsequent interviews or meetings whenever possible. The graphic display provides a sense of the flow of individuals through training programs and jobs but does not lend itself to summarizing the various types of quantitative information involved, such as the number of individuals entering the field each year, the various probabilities of reassignment among jobs, attending advanced technical training, or participating in PME courses. Such data, which are critical aspects of describing the specialty, are better conceptualized as a series of data matrices.

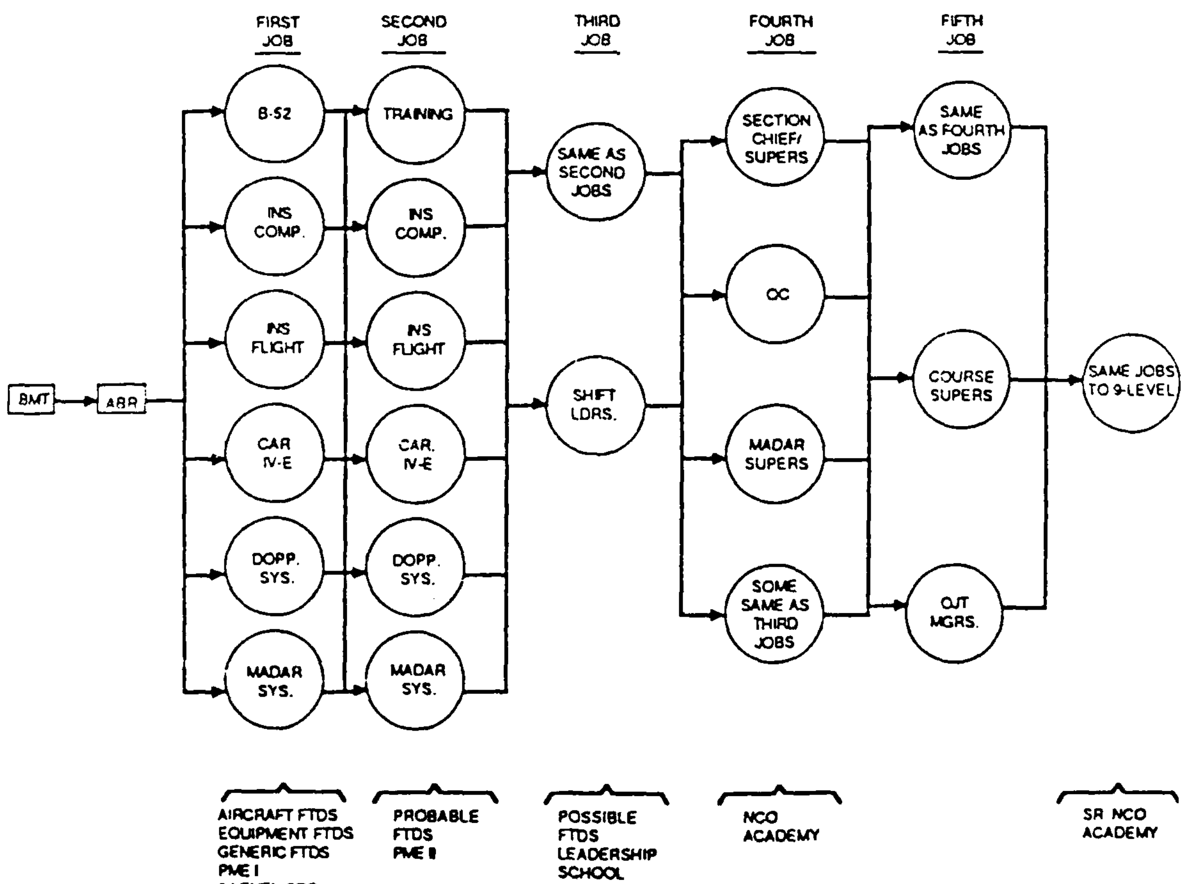

Figure 4. Current Utilization and Training Pattern for Avionic Inertial and Radar Navigation Systems (AFS 328X4).

Such data matrices summarize the probabilities of individuals being assigned to various jobs, of attending specialty-specific and PME training programs, and of exiting jobs for reassignment or to leave the specialty (or the Air Force). To adequately model the complex flows of personnel through specialty jobs and training programs, the TDS employs a dynamic simulation approach, which gives the analyst or researcher the capability to change specified values (i.e., number entering, relative assignment probabilities, attrition rates, etc.). Thus, the current U & T pattern can be modified to consider possible changes of the present approach to providing training or assigning personnel within the specialty; any such modification is considered an alternative U & T Pattern.

2.3.2.2 Alternative U & T Pattern Component. The second FUS component develops alternative U & T patterns which managers and commanders might wish to consider and evaluate. Such alternatives could include patterns that minimize initial skills training (limit the number of first-term jobs), that represent present proposals for change of the specialty (e.g., the programmed expansion of Air Base Ground Defense training to all new Security and Law Enforcement personnel), that represent logical restructuring of work in a specialty, that involve reorganization of training for a specialty, or that might possibly result from expected procurement of new equipment or new procedures. TDS handles most proposed changes as alternative U & T patterns and builds displays and data files to simulate the consequences of these changes. Figure 5 displays an example of an alternative U & T pattern for the current U & T pattern shown in Figure 4. Note in this example, the major change is to eliminate FTD training by adding trailer courses immediately after resident training for small (Fighters/Recon) and large (Strategic/Airlift) aircraft systems. The objective in this alternative is to ensure aircraft systems-specific training for everyone (FTD attendance is typically very limited) to ensure job qualification.

For the TDS development effort, ideas for alternative patterns were developed concurrently with the creation of the current U & T model. Interviews with HQ USAF, major command (MAJCOM), and functional managers were supplemented with information from technical school instructors and other SMEs. Other alternatives were constructed based on rational job

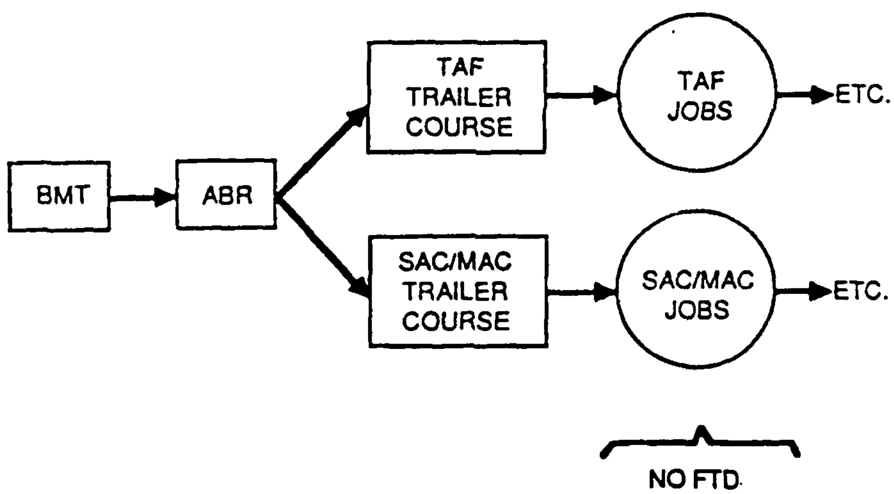

Figure 5. **Example of an Alternative Utilization and Training Pattern; Avionic Inertial and Radar Navigation Systems (AFS 328X4).**

engineering or to meet some objective function (i.e., reduce the number of initial job possibilities, minimize initial skills training, etc.). Whenever possible, developed alternatives were validated with SMEs, who examined them for plausibility and potential value. In most cases, the potential alternative U & T model was created by modifying some major element of the current U & T model; for example, the simplest change would be to increase or decrease the flow of personnel into the specialty.

In all cases, the implications of change had to be evaluated in terms of impact on flow of assignments, school attendance rates, etc. The structure of the FUS specialty model facilitates this process since it is necessary to consider how any change will be implemented as changes in the data. [In extreme cases, such as where new equipment is procured or where entirely new jobs are created, new data files would need to be constructed including new job descriptions and new training programs, as well as making modifications to job and training assignment flows.]

2.3.2.3 FUS Flow Simulation Program: A Dynamic Modeling Approach. A computer-based simulation program was developed for TDS as a tool to facilitate analysis of current and alternative U & T patterns, and to permit calculation of total specialty training requirements for each pattern. Such a simulation program is absolutely necessary for the TDS if we are to model and evaluate changes to any of the variables used to characterize specialty jobs, job content, training programs, course content, assignment probabilities, training capacities of units, and training costs or resources.

The dynamic simulation program is a major innovation in technology in terms of better estimation of OJT requirements for all jobs in the specialty. It considerably extends earlier research aimed at adapting econometric and manpower modeling to the issues of personnel assignment flows and training costs in operational units (Eisele, Bell, & Laidlaw, 1978; Rueter, Bell, & Malloy, 1980). Such a simulation is critical for calculating OJT requirements and costs realistically; any changes in job content, training programs, or even assignment probabilities have an impact either directly or indirectly on the requirement for OJT.

The program is a dynamic simulation system which processes descriptive data files in such a way as to show total numbers of personnel flowing through jobs and training programs over an extended period of time. Data can be examined by any specified period of time; training flows are generally expressed as annual rates where assignment probabilities are more realistically portrayed for 2- or 3-year intervals equivalent to the typical Air Force specialty job assignment. Such dynamic processing of several models (U & T patterns) of a specialty provides the needed flexibility to project future requirements and assess the consequences of proposed changes.

Existing programs, such as the Simulation Language for Alternative Modeling (SLAM), were found to be not fully adequate for handling the complex specialty models needed in the TDS. Several systems were examined and tested but were found to be unable to handle the complexities of most Air Force specialties (Yadrick et al., 1987). Thus, new simulation software was designed and tested which would meet the specific requirements of the TDS.

The new program is titled UTPSIM, the U & T Pattern Simulation Program. It uses data from the 10 files listed below to generate a flow pattern of entities (hypothetical individuals) moving from initial training course(s) through first jobs (and associated training) to advanced courses or new jobs over a full career. It also accounts for career field attrition (both cross-training to other specialties and leaving the Air Force), FTD and PME requirements, and other specialty-specific factors. Files used in generating UTPSIM models include:

RUNPAR = Run parameter file (includes required specifications)

JOBIDS = Titles and job identification information

JOBTTM = Percent people performing TTMs per job

TRNPAR = Titles, type, and length of courses

JOBTRN = Job-driven training probabilities (Option 1)

TIMTRN = TAFMS-driven training probabilities * (Option 2)

TJBTRN = Job- and time-driven training probabilities (Option 3)

ENTRYS = Number of people entering/transition probabilities

FRMJOB = Probabilities of entities exiting Specialty jobs

TOJOBS = Probabilities of entities entering Specialty jobs

* TAFMS = Total Active Federal Military Service

The output of the UTPSIM program is an Output Entity History File (OUTEHF) which contains the job and formal training history of each individual (entity). For any given set of input data (current or alternative U & T patterns, or variations of input parameters, such as annual input), the dynamic simulation calculates how individual entities enter the system, move through training and job states, and exit the specialty (or the Air Force). These data are processed in two additional programs (HISCRN and TRNPRF) to produce the final FUS output, as shown in Figure 6.

The History Screening (HISCRN) program is needed to eliminate those entities who are not in the equilibrium window (the period of interest in the simulation) and thus are not relevant for determining total OJT requirements of the specialty. The Training Proficiency (TRNPRF) program computes the total amount of OJT needed in the specialty for all individuals to achieve required proficiency on the tasks of the TTMs involved in their jobs.

The TRNPRF program uses two new data files not previously noted: the Allocation Curve file and the TTM-Course file. The Allocation Curve file contains parameters derived in the TCS which reflect how training is to be allocated to various training settings. There is a separate allocation curve for each TTM for each setting, and proficiency is assumed to be additive across settings. There are many different combinations of how training could be delivered which would result in achievement of required proficiency (100% = go level under AF OJT go/no go concept) on TTM tasks. Allocation curves also set an upper bound on the number of hours that are

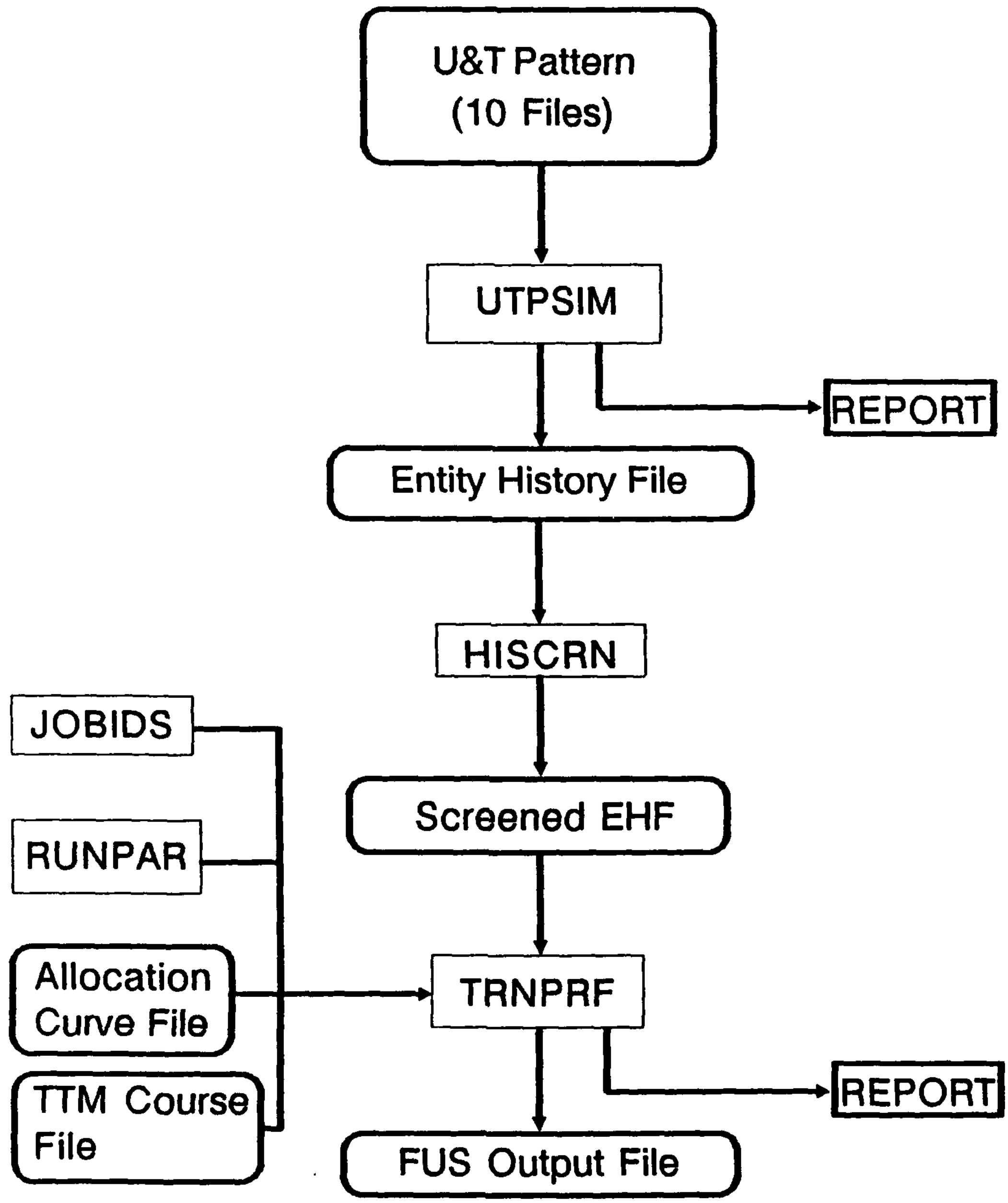

Figure 6. Relationship of FUS Simulation Programs.

worth providing in a setting in terms of the maximum proficiency that can be achieved in that setting (Perrin, Knight, Mitchell, Vaughan, & Yadrick, 1988; Vaughan, Mitchell, Marshall, Feldsott, & Rueter, 1988). This level sets an effective limit on the TTM training hours which should be delivered in the setting.

The Allocation Curve Parameter file contains a complex array of data for each TTM-by-setting combination (see Table 1). Such data include: TTM ID Number, Setting ID Number, Beta (squared regression coefficient of the allocation curve for the TTM-by-setting), Alpha (regression constant for the particular function), Current Allocation Hours (estimated hours on the TTM under current training), Ideal Allocation Hours, Maximum Time (the maximum effective training hours for the TTM), Minimum Time (minimum hours to achieve full proficiency), Maximum Proficiency (the maximum obtainable in this setting on the TTM), and Current Allocation Preference (rating, on a 0 to 4 scale).

All these types of data are necessary for the TRNPRF to be able to calculate OJT requirements for each TTM. For details of how the TRNPRF program operates to perform these calculations, see the TDS Procedural Guide (Vaughan, Mitchell, Marshall, Feldsott, & Rueter, 1988). For a discussion of how allocation curves are developed, see the TCS Administrative Report (Perrin, Knight, Mitchell, Vaughan, & Yadrick, 1988).

Table 1. Example Allocation Curve Parameter File Data for Four TTMs

TTM ID	Setting ID	Beta	Alpha	Current alloc.	Ideal hours	Max time	Min time	Max prof	Current pref
1	1	0.0000	0.1295	19.55	9.09	298.38	0.00	38.6	0.96
1	2	0.0033	0.9912	18.10	16.09	48.04	0.00	40.0	0.94
1	3	0.1578	6.3350	2.26	4.61	11.78	0.00	52.7	0.67
1	4	0.0536	4.6010	18.62	15.32	25.64	0.00	82.7	0.78
2	1	0.2049	7.1250	6.15	5.96	10.85	0.00	53.2	0.97
2	2	0.0232	2.0190	3.24	4.83	24.92	0.00	35.9	0.92
2	3	0.2289	7.1360	3.44	2.65	15.59	0.00	55.6	0.94
2	4	0.1149	6.0240	6.84	7.40	26.21	0.00	79.0	0.97
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
8	1	0.0000	0.7900	25.63	20.71	49.73	0.00	39.3	0.83
8	2	0.0059	0.1043	8.84	8.84	8.84	0.00	0.5	1.00
8	3	0.0154	1.4820	10.87	14.43	48.12	0.00	35.7	0.89
8	4	0.2138	9.4750	8.48	8.48	8.48	2.77	65.0	1.00
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
57	1	1.2340	16.8900	0.90	0.92	3.92	0.00	47.3	0.99
57	2	11.3200	34.9400	0.69	0.97	1.54	0.00	27.0	0.72
57	3	6.6640	41.3200	0.41	0.65	3.10	0.00	64.1	0.90
57	4	2.3450	32.7600	1.80	1.29	3.67	0.00	88.6	0.79

The TTM-Course file is based on data collected via a survey of the technical training center (TTC) and FTD instructors as well as OJT trainers in representative field units. Each course is assessed by one or more qualified SMEs (typically course instructors and/or course supervisors) and is characterized in terms of the number of hours of classroom time, hands-on training, and self-study time spent for each relevant TTM (see Table 2 for an example). Additional categories (such as administrative time, testing time, etc.) are allowed; the total time should equal the course length specified in AFR 50-5.

Table 2. Example Course Description Using TTMs (ABR32834 001 - Avionic Inertial and Radar Navigation Systems); 30 wks, 4 days (as of June 1986)

Task Training Modules	Classroom hours	Hands-on hours	Self-study hours
Block 1 - Electronics Fundamentals	672.0		
Block 2 - Avionics/Navigational Systems			
4. Training/OJT Program	6.0		2.0
9. Inspect Workcenter Equipment	3.0	6.0	2.0
17. Liaison with Job Control	2.0	2.0	1.0
22. Maintain/Prepare Tech. Orders	1.0		.5
24. Nav. Equip. Maint. On Acft	20.0	15.0	8.0
25. Inertial System	75.0	22.0	12.0
26. Navigation Unit Components	9.5	1.0	2.5
31. Doppler Systems Off-Equipment	16.0	4.0	
32. Doppler Systems On-Equipment	19.0	16.0	
33. Doppler Nav. Comp. Cards	.5		
34. Doppler Sensor Control Boxs	.5	1.0	
36. A/C Wiring Harness	2.0		
44. Gen Purpose Nav Comp On Acft	32.0	6.0	10.0
45. Gen Purpose Nav Comp Off Acft	33.0	33.0	4.0
50. Relay Panels & INS Temp Bulbs	1.0		.5
59. Maintain WRCS	26.0	25.0	6.0
61. Weapons Release System	24.0	12.0	6.0
67. Heading Computers/Recon. Adapt.	2.0	2.0	1.0
68. Maint Inert. Comp/Off Equipment	31.0	24.5	8.0
73. Maint/Program Nav Units	5.5	3.5	2.0
Subtotals (Block 2)	309.0	173.0	65.5
Block 1 & 2 Classroom + Hands-On		1154.0	
Additional Course Hours:			
Misc. (Career progression, etc.)		20.0	
Administration (Tests, processing, etc.)		32.0	
Military training (PT, drill & ceremonies, etc.)		26.0	
Overall ABR Course Hours		1232.0	

Data for all courses of the specialty are combined into a matrix of courses versus TTMs; cell entries represent total hours of instruction (classroom plus hands-on training) provided by each course. By describing all courses in terms of TTMs (as jobs were described earlier), it becomes possible to vary course content (presence or absence of TTMs) as well as hours of training per TTM in calculations of total specialty training requirements (in the TRNPRF). This provides the structured flexibility needed in the system to be able to consider alternatives to the courses and training hours of the current utilization and training pattern.

2.3.2.4 Management Preferences Component: Comparing Managers' Preferences. A third component of the TCS subsystem consists of a methodology for obtaining, analyzing, and displaying managers' preferences among various possible training and assignment patterns. Such preference data are collected from mid-level training managers, functional managers (HQ USAF and MAJCOM), and other senior AFS personnel; this permits a comparison among the various types of managers, to make visible any possible policy differences. If the U & T preferences are similar for various groups of raters, they can simply be averaged; if they represent distinctly different policies, then senior Air Force managers must decide which preferences to use in making decisions on specialty restructuring or solving optimization questions in the system.

The U & T pattern narratives and diagrams are assembled into survey booklets and administered to managers of the specialty. It is best to do this in a structured interview or supervised group administration session. Meetings of a TPT, U & TW, or other specialty conference are excellent opportunities for such data collection. Group sessions or structured interviews ensure standardized survey administration and allow managers to ask clarifying questions. Typically, as involved AFS managers, participants have their own ideas for changes in the AFS structure or training programs; such suggestions need to be documented for further evaluation. Survey booklets should include an open-ended option where managers can describe and rate "Other" alternatives.

Results of preference surveys need to be analyzed in terms of their internal consistency and possible group differences. An analyst should check for such differences through subgroup comparisons of rating patterns. (GRPREL programs are available in ASCII CODAP to accomplish this assessment.) Logical candidates for comparison are field (MAJCOM) versus training, HQ or functional versus training, etc. If no major group differences in rating patterns are found, then analysis can proceed to build displays of preferences among the alternative U & T patterns considered. If there are significant differences among rating patterns, then more complex displays will be needed to properly characterize preferences. Results should be included in a formal report or presented to specialty conferences (TPT, U & TW, etc.) for consideration. An example of such a summary of U & T preferences is displayed in Table 3.

It should be noted that in this hypothetical example, each group has its own preferred alternative; the overall average is heavily influenced by the largest group in the sample (MAJCOM managers). In most AFSs studied, differences were not this clearcut. The point of the example is that when such policy differences are present, they need to be made visible as a starting point for discussion and negotiation.

Table 3. Group Preferences for U & T Pattern Alternatives

Type Of Manager	(N =)	CURRENT U&T	ALT. 1	ALT. 2	ALT. 3	ALT. 4	ALT. 5	ALT. 6
HQ USAF	(3)	6.7	7.0	4.7	5.7	3.7	5.7	5.3
MAJCOM	(6)	4.8	4.5	3.7	3.2	1.7	3.5	8.2
TRAINERS	(4)	6.25	4.0	5.5	8.0	2.0	7.0	4.5
PERSONNEL	(2)	3.5	2.0	5.0	4.5	8.5	7.0	6.0
OVERALL	(15)	5.39	4.53	4.55	5.15	3.09	5.34	6.34

1 = low preference, 9 = high preference

In the TDS, management preferences are not a final decision, but, rather, serve as the starting point for evaluating possible alternative decisions on the basis of their potential desirability, costs, and consequences. Managers may elect to have only selected (highly preferred) alternatives evaluated further, or they may decide to construct some new alternative (a composite of several proposals or new ideas) which may require new data gathering for further consideration and evaluation. In any event, some products of the FUS and TCS subsystems, representing considered managers' decisions, become basic input variables for the operation of the Resource/Cost Subsystem.

2.3.3 Resource/Cost Subsystem (RCS)

The RCS was developed to provide TDS three distinct, yet interrelated, analytic capabilities:

1. determination of the types and amounts of resources required to provide training on each TTM in each training setting, and estimation of the amounts of those resources available for use in providing training at each site;

2. assessment of the capacities of various sites to accommodate differing volumes of training on different combinations of TTMs in different training states, where a training state consists of a set of specific amounts of training conducted on specific TTMs in particular training settings; and

3. estimation of the variable costs that must be incurred in providing training on each TTM in each training setting, and in providing particular volumes of training in specific training states.

To accomplish these objectives, the RCS is structured into three analytic components: a Resource Requirements Component (RRC), a Training

Capacity Component (TCC), and a Cost Estimation Component (CEC). These components use input files from the TCS and FUS; compile resource requirements, availability and cost factor data; and interact with one another to generate resource and cost estimates (see Figure 7; see also Rueter, Vaughan, & Feldsott, 1988). Training resource requirements are classified into several categories (such as variable versus fixed, exclusive versus shared) to facilitate estimating training capacities and training costs (see Figure 8).

2.3.3.1 Resource Requirements Component. The RRC performs five data development functions. Specifically, it (a) determines the specific types of resources required to perform training on each TTM in each training setting, (b) estimates the quantity of each identified type of resource required for training each TTM in each setting, (c) produces compilations of those estimates classified on the basis of the ways in which the corresponding types of resources affect variable training costs and training capacities, (d) estimates the quantities of those resources available for the provision of training at various actual sites, and (e) delineates an appropriate set of representative sites for the particular specialty.

Inputs to this component include: TTM definitions and amounts of time allocated for training the various TTMs in different training settings (from the TCS), and preliminary lists of resources required for training each TTM in each setting (collected via a Training Requirements Questionnaire administered to school and field trainers; see example in Figure 9). Based on these inputs, an analyst identifies representative sites and develops the basic data for use in estimating training capacities and costs within the other two RCS components.

Representative sites (TTC courses, FTD courses, operational units) are identified to account for important locational variations in travel and temporary duty (TDY) costs, training loads, missions, resource availability, and other factors. The use of representative sites permits more economical collection of cost data and simplifies comparisons of resource availability and resource requirements. A key consideration in determining resource availability is the identification of the minimum resources required for operational duties at representative sites, since operational requirements place real constraints on the training capability of a unit.

2.3.3.2 Training Capacity Component. The TCC evaluates the capacities of various representative sites to provide training in appropriate settings on different combinations of TTMs and in training volumes that are compatible with the U & T patterns identified in the FUS. Inputs to this component consist of the following: TTM combinations and training volumes for the various U & T patterns (from the FUS), predicted amounts of specific resources required for the provision of training on each TTM in each training setting (in the form of regression equations from the RRC), and availabilities of those resources for providing training at each representative site. Resource availability data are collected in a Training Resources Availability survey of TTCs, FTDs, and representative field units (see example in Figure 10). For dedicated training resources, data on the sharing of equipment and other resources must be collected since sharing has a potential impact on training capability, and may vary by site.

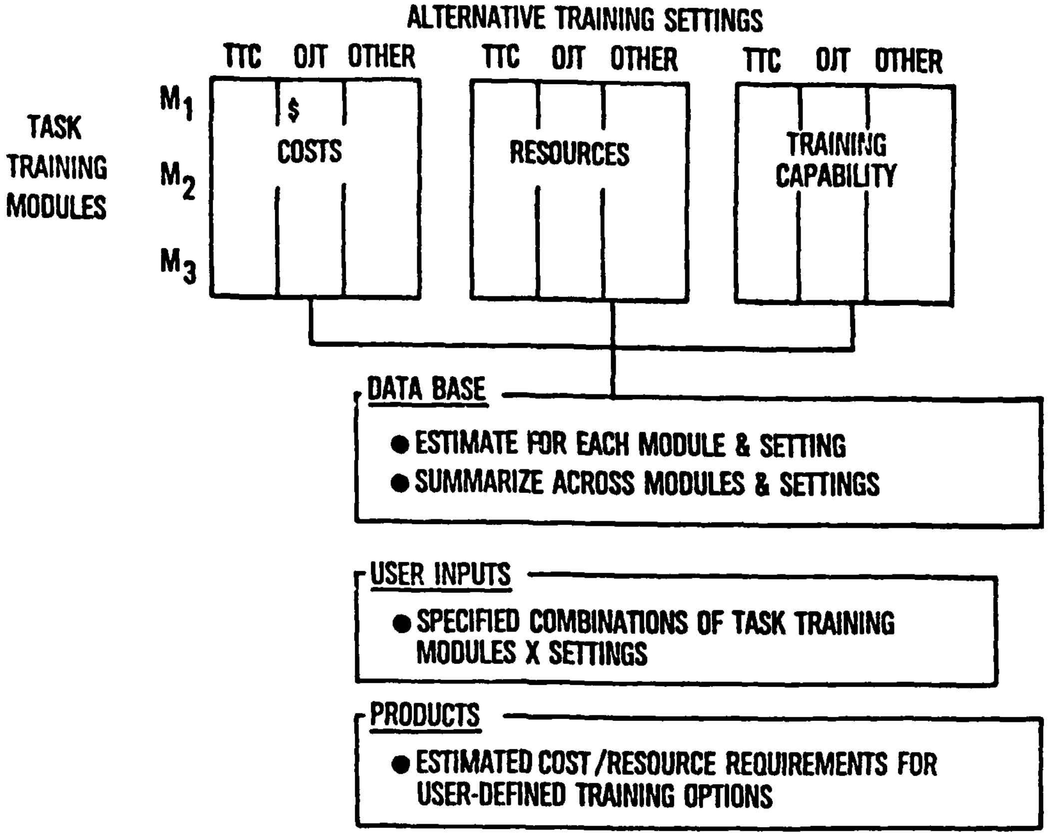

Figure 7. The TDS Resource/Cost Subsystem (RCS).

RESOURCE TYPE / RESOURCE USE	VARIABLE: PRIMARILY AFFECTING VARIABLE TRAINING COSTS	FIXED: AFFECTING TRAINING CAPACITY
EXCLUSIVE WITHIN TTM	RESIDENT SCHOOL STUDENT TIME RESIDENT SCHOOL TRAINER TIME	MEDIA AIDS
SHARED:		
• WITH TRAINING ON OTHER TTMs IN SAME AFS	COURSE MATERIALS TRAINING SUPERVISOR TIME RESIDENT SCHOOL SUPPORT PERSONNEL TIME	TRAINING EQUIPMENT LABORATORY SPACE RESIDENT SCHOOL SUPPORT FACILITIES
• WITH TRAINING ON OTHER AFSs	TRAINING BASE SUPPORT PERSONNEL TIME	CLASSROOM SPACE TRAINING BASE SUPPORT FACILITIES
• BETWEEN TRAINING AND OPERATIONAL DUTIES	OJT STUDENT TIME OJT TRAINER TIME	OPERATIONAL EQUIPMENT OPERATIONAL BASE SUPPORT FACILITIES

Figure 8. The RCS General Resource Classification Scheme.

TASK MODULE 63 : Maintain Floppy Disc Program

TYPE OF TRAINING: Hands-on experience on-the-job including observing others, practicing the tasks & receiving direction (qualification & upgrade training)

FOR THE TYPE OF TRAINING INDICATED ABOVE AND FOR THE GROUP OF TASKS ON THE OPPOSITE PAGE, PLEASE INDICATE THE FOLLOWING RESOURCE-SPECIFIC INFORMATION:

COLUMN A	B	C	D	E	F	G	H
	Current Training: ______ Hours			Ideal Training: ______ Hours			
Resource	Number of hours each trainee must spend working with resource item.	If resource item is shared, indicate the maximum number of trainees that can effectively share the resource simultaneously.	If resource item requires instructor demonstration time, indicate number of instructor demonstration hours required.	Number of hours each trainee must spend working with resource item.	If resource item is shared, indicate the maximum number of trainees that can effectively share the resource simultaneously.	If resource item requires instructor demonstration time, indicate number of instructor demonstration hours required.	Total training time before you would start/stop using resource item.
Diagnostic Program							
Digital Voltmeters or Multimeters							
General Tool Kit							
Oscilloscopes							

	Current Training	Ideal Training
Total instructor time for:		
Instruction (including time working with resources)	______	______
Preparation/Administration (if known)	______	______
Total trainee time (including preparation)	______	______

Figure 9. Example Training Resource Requirements Questionnaire

Resource Item A	Number Available for Use in OJT in AFS 328X4 B	Hours Per Day/ Week/Month (Circle Relevant Time Period) Item is Available for Use C
039 Aircraft		
040 Antenna Simulator (NSA-90)		
005 AN/USM-74 Computer Test Sets		
041 Audio Oscillators		
042 Box Test Fixtures		
064 Chart Recorders		
069 Crystal Checkers		
070 Decade Dividers		
071 Decade Resistors		
073 Differential Voltmeters		
105 Digital Probes		
172 Digital Voltmeters		
074 Doppler Simulators		
077 Frequency Counters		
078 Frequency Meters		
083 Integrating Digital Voltmeters		
093 Load Simulators		
098 Meggers		
102 Microwave Test Lines		

Figure 10. Example of a Training Resource Availability Questionnaire.

An analyst develops estimates of the capacity of each representative site to accommodate various combinations of TTMs and training loads, and identifies any resource limitations that constrain representative sites from accommodating particular U & T patterns. When such constraints are encountered, they are displayed in the OJT Capacity Report for each site as "Trainees Unsupportable" (see Table 4; note training deficit of 18 trainees imposed by Resource 39).

Table 4. Example of a Representative Site Training Capacity Report (Adapted from AFS 328X4 Report, 15 Feb 88, Table 8.1)

REPRESENTATIVE SITE: 1
Training Capacity: - Upper Bound: 18; Lower Bound: 12
Total Trainees Required: 30

Resource ID	Amount Avail.	Amount Required	Avail/Req Ratio	Max Trnees Supportable	Trainees Required	Trainees Unsupportable
18	5840.0	0.2	30917.65	826695.	26	0
27	1800.0	7.9	227.27	6782.	29	0
39	208.0	511.9	0.41	12.	30	18 <<<<
68	1560.0	2.0	5902.30	111941.	30	0
91	520.0	1.9	277.42	7543.	27	0
104	5840.0	29.8	195.97	5864.	30	0
150	17520.0	61.6	284.49	8658.	30	0
160	52.0	36.7	1.42	39.	27	0
183	8760.0	0.7	13431.01	82007.	6	0
.						
.						
.						

Inherent in this process is evaluation of the feasibility of resource substitution, the impact of training load on training quality, and the possible impact of training on mission performance (where a training deficit exists, then resources must be diverted from mission performance to provide training, or the unit runs the risk of error or accident which may result from the lack of complete training). Training capacity evaluations use statistical training resource requirement functions and mathematical programming formulations to assess various training options.

2.3.3.3 Cost Estimation Component. The CEC computes total annual variable costs for providing training of each TTM in each training setting (assuming all required resources are available in sufficient quantities), and then compiles the cost estimates in a form compatible with the estimates developed for training capacity. Inputs to this process include: estimated training resource requirements (from the RRC), training states (i.e., amounts of time allocated to specific TTMs in specific settings) and associated training volumes compatible with various U&T patterns (from the FUS), and unit resource cost factors from external Air Force data sources (TDY costs, instructor salary levels, costs of training equipment and supplies, etc.). By applying the unit cost factors to the estimated training resource requirements for the specified training states and training volumes, this component estimates the variable costs of conducting training in each training setting and for each specified training volume in the corresponding training state.

Once these very complex basic data sets have been developed, they must be synthesized and processed as formatted reports in such a way as to be useful for Air Force decision makers. This is done by operation of the RCS components and data files as shown in Figure 11. The common starting point is the FUS Output File (from TRNPRF). Multiple processing is performed to generate training hours for trainees, trainers, and other resources, for both classroom and OJT requirements. It should be noted that the capacity and costing programs of the RCS operate in parallel, use some common data files as input, and use some unique files as well. The major products of the RCS are data files and reports; these are organized by representative site, training setting, and job. An example capacity report was given earlier (Table 4); Table 5 provides an example of a cost report for representative sites for the same Air Force specialty.

Such unit-level data are also aggregated to derive estimates for the total AFS, for MAJCOMs, and for individual bases in a summary section of the report. Separate reports of training capacity and costs are generated for the current U & T pattern and each alternative U & T pattern to create multiple RCS output files. [For more details on the RCS and its components, see Rueter et al., 1988.] RCS data files serve as the basis for comparing the impact of various suggested AFS changes, and for generating reports to respond to managers' inquiries, through the operations of the Integration and Optimization Subsystem (IOS).

2.3.4 Integration and Optimization Subsystem (IOS)

The IOS ties together the other three subsystems into one overall functional system (as shown earlier in Figure 1). The IOS contains mechanisms which enable system modeling and optimization. The interconnections of the subsystems provide the capacity to optimize measures derived from one subsystem relative to constraints obtained from the others, and to simultaneously process data files derived from different subsystems. The IOS also provides the interface with users; that is, the subsystem receives all requests, calls appropriate data from the other subsystems or TDS files, and creates products to meet the users' needs. In all of its functions, the IOS governs the interaction among the TDS subsystems and various data sources, and the relationship of the system with various types of users. The IOS is structured to perform three types of functions:

2.3.4.1 Modeling Functions. The IOS processes information and data files from the TCS, FUS, and RCS to create various models of the AFS under consideration. The basic model for the AFS is the current U & T pattern; each alternative U & T pattern represents some change to the current U & T model. This approach provides maximum flexibility in the TDS, since an almost infinite number of possibilities can be considered.

The modeling functions of the IOS are not limited to examining the alternative U & T patterns formulated in the FUS (although AFS managers' preferences are collected only for these alternatives). Rather, IOS modeling provides the capability to change any input variable for any program, thus permitting examination of the impact of such change on the total system. For example, the simplest change would be to use the current FUS model and raise or lower the number of personnel entering the ABR course (modify the Trained Personnel Requirement or TPR). The system

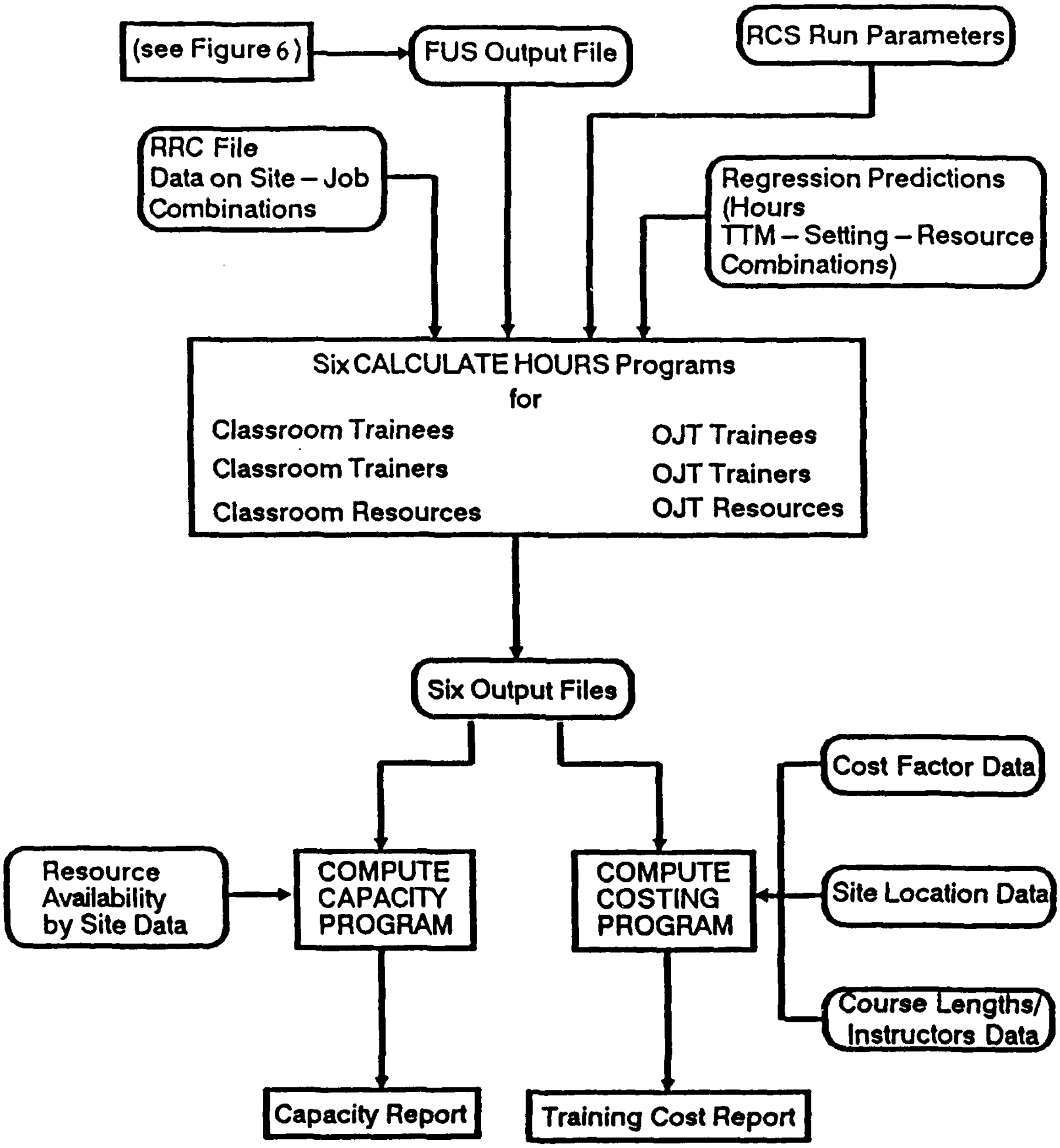

Figure 11. Interrelationships Among RCS Inputs, Components, and Products.

Table 5. Total Air Force Direct OJT Costs by Job and Representative Site (Total Trainee and Trainer Salaries + Other Costs)

DIRECT OJT COSTS

AVIONIC INERTIAL & RADAR NAVIGATION SYSTEMS (AFS 328X4)

(in Thousands of $)

	-------REPRESENTATIVE					SITES-------			
JOB	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9
1	0.0	0.0	0.0	190.9	95.5	0.0	916.5	610.9	0.0
2	1654.0	6616.9	0.0	1985.1	661.7	0.0	19339.6	661.7	0.0
3	3460.8	0.0	0.0	598.5	0.0	0.0	3877.1	0.0	0.0
4	279.7	0.0	0.0	0.0	0.0	0.0	69.9	0.0	0.0
5	358.5	0.0	0.0	0.0	167.3	0.0	740.9	0.0	0.0
6	577.2	0.0	0.0	1487.4	0.0	0.0	88.8	777.0	0.0
7	92.0	57.5	0.0	218.5	0.0	0.0	0.0	0.0	0.0
8	93.5	2032.9	0.0	4392.9	0.0	0.0	0.0	397.2	0.0
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
21	319.8	1670.4	1315.0	1670.4	995.1	0.0	995.1	5046.6	1314.9
22	0.0	125.2	0.0	801.4	0.0	0.0	0.0	125.2	0.0
23	0.0	0.0	0.0	0.0	603.7	0.0	0.0	0.0	0.0
24	0.0	13.2	0.0	39.7	13.2	0.0	13.2	0.0	0.0
25	42.9	0.0	42.9	0.0	1115.1	0.0	0.0	0.0	0.0
26	0.0	19.9	0.0	1054.1	0.0	0.0	0.0	0.0	0.0
27	60.8	243.2	60.8	1378.1	729.6	20.3	121.6	830.9	830.9

Note: Jobs equate to those shown in Figure 4. Representative sites are typical organizational units with a characteristic combination of missions, weapon systems, or set of jobs, used as a basis for estimating average training capacities and costs (see Table 4 for Site 1 training capacity report).

would then generate reports for comparison with the data from a baseline current U & T pattern run; differences in values (annual training costs, total AFS population in future years, etc.) would reflect the relative impact of the change. Another type of change would be to change the content of some course, such as the ABR, and then run the system to assess the changes in costs and total OJT requirements for the specialty.

Any major proposed change in a specialty should be dealt with as a formal alternative U & T pattern, so that possible consequences can be examined in some detail and data collected which describe Air Force managers' preferences among a set of alternatives. Some changes, such as a merger of several AFSs at the technician level (as proposed in RIVET WORKFORCE), may exceed present system capacities (unless a new OSR is accomplished using a redeveloped task list covering all specialties involved, or needed data are estimated in some other way).

Most of the possible changes which might be considered for an AFS can be modeled by changing input parameters, course content, job content, or career patterns within the TDS. Such changes are processed as modeling runs with specified values of selected variables. Analysis then focuses on how such changes impact on training capacity and total training costs. The training capacity reports generated in this process will also highlight any constraints on training capability in terms of training equipment, instructor availability, or other significant problems.

An example may serve to illustrate how potential changes can be evaluated. The problem might be a resource constraint in conducting OJT in some units, such as not enough hours when a piece of test equipment--a Weapons Release Control System (WRCS) Analyzer in the Radar and Inertial Navigation Systems Maintenance specialty (AFS 328X4)--is available for use in training. One approach to the problem would be to move training of that equipment from an OJT setting to a formal course (an FTD or the basic resident course at the TTC). The first possibility can be modeled in the TDS by adding enough hours to achieve the required proficiency (as indicated by the Allocation Curve for the WRCS TTM) to the resident course. A second model would be to add hours for this training to the FTD course.

The results of these analyses are shown in Table 6, along with data from the current U & T pattern as a baseline for comparison. It should be noted that the "Exceeded" under the current U & T pattern (first column) indicates that some resource constraint exists (in this case, an equipment availability constraint). Note also that the proposed solution of adding the required WRCS Analyzer training to the FTD (third column, far right) did not solve the problem; OJT capacity is still exceeded. Moving the training to the resident (second column, middle) course does appear to solve the constraint problem, but at an additional ABR cost of about $20,000. There is, however, some offsetting reduction in OJT costs since WRCS Analyzer training was removed. In this particular example, the costs calculate out to be about the same but providing the training in the ABR does not exceed OJT capacity of units in the field. Obviously, this is a feasible and practical solution.

The point here is that once a problem and potential solutions have been identified, the IOS modeling capability can be used to translate the

Table 6. Comparison of AFS 328X4 U & T Patterns Involving Movement of WCRS Analyzer Training (ABR = Airman Basic Resident; FTD = Field Training Detachment)

	CURRENT U&T PATTERN	AUGMENTED ABR COURSE	AUGMENTED FTD COURSE
ABR COURSE COSTS	$1,676,352	$1,696,406	$1,676,352
FTD COURSE COSTS	$ 45,647	$ 45,647	$ 53,495
TOTAL COURSES	$2,724,296	$2,744,350	$2,732,145
OJT COSTS	$5,096,500	$5,076,792	$5,095,981
OJT CAPACITY	EXCEEDED	NOT EXCEEDED	EXCEEDED

potential solutions into modifications of the specialty data base (the current U & T files). The TDS software is then employed to generate products for each potential solution and results can be compared to baseline data (current U & T products) by Air Force decision makers.

2.3.4.2 Optimization Functions. Given the almost limitless number of possible changes which might be studied, a TDS analyst or functional user might wish to take another approach to assessing specialty training changes. This approach could make use of the IOS optimization software. The analyst or user can specify an objective function or goal (such as minimization of OJT cost or total training costs, or maximization of the amount of available equipment, etc.), run the optimization program, and examine the effects on the specialty if the objective function is maximized or minimized. The analyst can ask "What if" questions; for example:

> What is the impact on total training costs if we minimize initial resident course instruction?
>
> What happens to specialty jobs (proficiency) if we maximize FTD training and minimize OJT?
>
> What is the impact on proficiency acquisition and training costs if we have a 10% cut in new recruits entering training?

Some potential optimization problems may become visible during modeling runs of the specialty as training constraints are identified, or possible new models may be suggested by initial optimization runs (see Figure 12). Other possible optimizations will be suggested by general Air Force trends, such as budget cuts or changing operational priorities. In some cases, these could be complex problems with several constraints and multiple values to be optimized.

The approach taken in employing optimization algorithms to solve maximization or minimization problems in the TDS is to employ modular data bases and seek solutions at the lowest possible level. This isolates

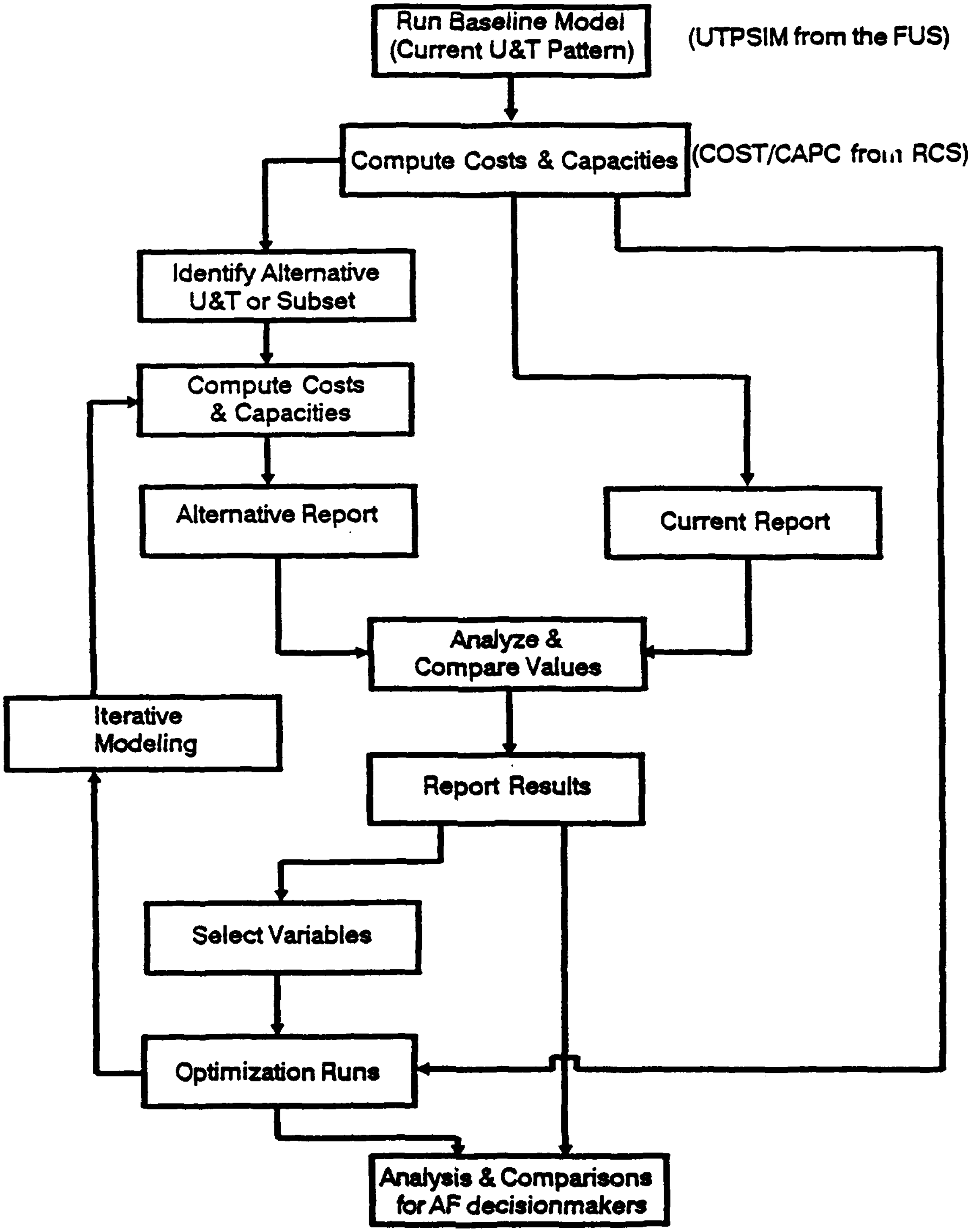

Figure 12. Relationship of Modeling and Optimization Functions of the IOS.

solutions to only the area of interest and has considerable efficiency in terms of saving computer time. Only the largest optimization problems, such as minimizing total specialty training costs, would require employment of the entire TDS data base. More limited problems can thus be dealt with by limited program runs.

The computer programs used to provide optimization runs were designed so that they can be interfaced with TDS data bases in the IOS. A detailed review of such software is beyond the scope of this overview report. For details of constraints, available routines, and procedures for using such software, see the TDS Procedural Guide (Vaughan, Mitchell, Marshall, Feldsott, & Rueter, 1988).

2.3.4.3 User Interface Functions. The IOS also serves as an interface with TDS users. It receives all requests, calls appropriate data from the other subsystems or TDS files, and creates products to meet the users' needs. In its present configuration, the interface is handled through on-line computer requests (control cards, specification of variables, creation of required data files) and the resulting products (data files and reports).

At present, the IOS interface is structured for separate modeling and optimization runs. This design permits selection of the work to be done without requiring that both processes be engaged. It also offers considerable flexibility in that the user can select the desired function and complete a full run or simply engage a routine for additional analysis as needed. This modularization is a necessary efficiency at the present stage of TDS development. Creation of fully interactive IOS software (to create menus, options to be specified, and automated report formats) at this stage would be counterproductive, since not all of the parameters and desired report formats are known. Rather, this aspect of IOS user interface software must be deferred until after completion of sensitivity analysis and the full Test and Evaluation (T & E) of the system.

2.4 TDS Software

The present TDS subsystems software packages were initially constructed on VAX computers at McDonnell Douglas Astronautics in St. Louis and the CONSAD Research Corporation in Pittsburgh. After complete development and testing on these systems, TDS software was transferred to the AFHRL UNISYS 1100 system for testing, debugging, and validation. All TDS software was written in Fortran so that it would be transportable between computer systems; however, some reprogramming proved necessary to accommodate AFHRL-unique PRISM interface programs and to meet AFHRL Information Sciences Division standards.

The TDS is now resident on the AFHRL UNISYS computer system and has undergone initial testing and validation. Additional testing is planned; the present contract was modified to include a sensitivity analysis to assess the impact of changes in various types of data on system output. In addition, the contract modification required planning and conducting a full test and evaluation of the system. These activities will be summarized in a separate report.

3. POTENTIAL TDS USES AND USERS

The TDS is designed to service a number of different types of Air Force decision makers. One of the major tasks in the TDS development effort was to identify potential users of the system and to take their interests, requirements, and needs into account in planning and developing the system (see Mitchell, Sturdevant, Vaughan, and Rueter, 1987). This information was used to refine the TDS preliminary design (Vaughan, Yadrick, Perrin, Cooley, Dunteman, Clark, & Rueter, 1984) and to construct a plan for transitioning the TDS into an operational Air Force program (Vaughan, Yadrick, Perrin, Mitchell, Sturdevant, Rueter, & Ward, 1985). The final objective of these efforts was to create a draft Air Force Regulation to implement the system (see Appendix A).

This chapter briefly reviews the potential users of the TDS in order to establish the range of possibilities for employment of the system. (For a discussion of the visits, conferences, and other contacts with Air Force personnel and organizations on which this information is based, see Mitchell et al., 1987.)

3.1 TDS Users

A number of potential users of the TDS were identified and their needs considered in the development of the system.

3.1.1 HQ USAF

One of the major functions of the TDS is to provide services to the Air Staff for the Planning, Programming, and Budgeting System (PPBS). Currently, such planning and programming focus primarily on budgeting for formal technical training since OJT requirements and costs are not visible in the system (Rueter, Bell, & Malloy, 1980). Making all Air Force specialty training requirements visible and creating realistic estimates of OJT have been central themes in the development of the TDS, and they have been fully accommodated in the design of the FUS and RCS. Such data should be extremely useful for HQ USAF functional managers and training planning staffs. Alternative U & T patterns allow such managers to consider major planning options. The ability of the IOS to provide data estimates for "what if" questions should be invaluable as a major planning tool.

3.1.2 Training Planning Teams

Another anticipated major use of the system is to service the needs of Training Planning Teams (TPTs), which are multi-command teams convened by the Air Staff (functional manager or other major staff element) through issuance of appropriate programming documents (see AFR 50-8, 6 Aug 84, paragraph 3b). The TPT process is a recent Air Force innovation which is still being evolved (for details of 1984 - 1987 TPT responsibilities and participation, see Mitchell et al., 1987, pp. 32-45). Currently, a draft revision of AFR 50-23 is being coordinated within Headquarters USAF and with MAJCOMs which will limit TPTs to new weapon systems acquisition projects and authorize U & T Workshops as the primary forum for specialty-specific training requirements decisions.

To effect some major change resulting from acquisition of a new weapon system, TPTs must build a Training Development Plan (TDP). The initial step in building such a plan is the development of a comprehensive description of present U & T patterns for the Air Force specialties involved (like the specialty models of the TDS). TDS cost and resource estimation procedures may provide a way to realistically evaluate the cost implications of a proposed change to individual specialties. In addition, the IOS optimization capabilities could provide TPTs with the ability to visualize and evaluate the potential consequences of their decisions on a real-time basis. Thus, the TDS could help a TPT make more realistic and economically viable recommendations for major changes in specialty training and utilization programs.

3.1.3 Air Force Specialty Utilization and Training Workshops

U & TWs are routinely convened by HQ ATC so that training managers can meet with user command representatives to review present utilization and training programs (see AFR 8-13). Such meetings are called in response to user command requests for changes in training, as a result of training evaluation feedback, or upon completion of a new occupational survey. Typically in the past U & TW meetings have focused on initial skills training programs and the Specialty Training Standard (STS) for a particular Air Force specialty or set of related specialties, since detailed information on other training programs (FTDs, MTTs, and OJT) has not been readily available to all participants. As with the TPT process, the TDS could assist U & TW representatives in understanding present training and assignment patterns and in properly evaluating various proposals for change. [As noted earlier, a draft AFR 50-23 will upgrade U & TWs as the primary decision making process for individual Air Force specialties.]

3.1.4 AFMPC and AFMEA

In addition to Air Staff, TPT, and U & TW use, the TDS is also intended for use by Air Force Military Personnel Center (AFMPC) and Air Force Management Engineering Agency (AFMEA) planners and managers. For example, the Classification function at AFMPC could evaluate recommended AFR 39-1 changes in terms of their implications for AFS jobs, training programs, and related costs before approving or rejecting a proposal. AFMEA might use the TDS to assess the effects of manpower cuts on an AFS, or to examine job reengineering alternatives for reallocating manpower authorizations within a specialty. These potential uses for the TDS are largely conjectural; additional research and development would be required to explore such possible classification and manpower use of the system.

3.1.5 ATC or MAJCOM Functional and Training Managers

Such managers could use the system to evaluate ideas and proposals, to secure needed training and assignment pattern information, or to obtain data on how other commands and agencies conduct training in a specialty or how they are utilizing AFS personnel. In addition, training managers and developers at ATC Technical Training Centers, MAJCOM-designated training development units, or FTD remote locations could address the system for assistance in defining training requirements, preparing job descriptions (defined by sets of TTMs), and determining relative training costs.

3.1.6 USAF Occupational Measurement Center (USAFOMC)

The USAFOMC is responsible for Weighted Airman Promotion System (WAPS) test development, the Air Force occupational analysis (OA) program, Military Training Standard (MTS) development and training packages, and providing training analysis and development services to Technical Training Centers and other users. USAFOMC provides support services for U & TWs and TPTs, and has been responsible for developing Training Development Plans (TDPs) or Training Requirements Analysis (TRAs) for several AFSs. Some of the data requirements of TDPs and TRAs are typical TDS products (such as the current U & T pattern description), and the TDS can provide considerable assistance to the USAFOMC in servicing this type of function.

Because TDS studies begin with the specialty task list and OS data, the TDS could provide meaningful feedback to the OA program, and perhaps suggest further potential improvements to the OA process. For example, task clustering procedures developed for the TDS have already been enhanced (through a CODAP improvement project) and implemented into the OA program at USAFOMC. The task modules defined for TDS may be useful in revising the organization of task inventories. Several other TDS innovations (such as AFS modeling) have considerable potential for use in the operational OA program (Mitchell, Vaughan, Yadrick, & Collins, 1987; Mitchell, Vaughan, Yadrick, Collins, & Hernandez, 1988).

3.1.7 The Research Community

As other AFHRL research programs come to fruition, the types of data provided by the TDS (task clusters or TTMs, U & T patterns, alternative training possibilities, training cost and capacity estimates, etc.) may be applied in a number of innovative ways to help improve Air Force MPT programs. The TDS can provide data on specialty jobs and training requirements (for both current and proposed AFS utilization patterns) and training costs which may be needed to implement the Advanced On-the-job Training System (AOTS); in turn, AOTS potentially can provide new types of data which may be useful in future TDS development, such as procedures for determining prerequisite knowledge requirements or new task proficiency measures. In addition, the TDS itself and one or more of its subsystems may be useful research tools to explore the effects of systematic changes of job-entry aptitude requirements, student flows, or other parameters on AFS training programs and job content. As the system evolves, additional possible interactions among MPT research projects may emerge; these efforts could be made synergistic (Ruck & Mitchell, 1987).

3.2 TDS User Interface

As developed in this initial R&D effort, the TDS is designed to operate on the AFHRL UNISYS 1100 computer, and thus must be addressed via an AFHRL task scientist or system manager. The system is presently a completed R&D product although, as noted earlier, it will undergo extensive test and evaluation as well as sensitivity analysis.

The system may eventually be addressable to some authorized users via another computer system which could interface with the AFHRL system. In the planned follow-on R&D, an operational version of the system will be hosted

on another system. The most likely candidate, as noted in the TDS Transition Plan (Vaughan, Yadrick, Perrin, Mitchell, Sturdevant, Rueter, & Ward, 1985), is the USAFOMC IBM computer at Randolph AFB, Texas. Once the system is installed on that (or an equivalent) system, major users could be granted access via a dial-up capability using a modem and remote computer terminal. Such service would, however, be contingent on the development of additional software to support remote terminal operations.

4. DISCUSSION OF ISSUES

The research and development resulting in a proof-of-concept Training Decisions System (TDS) has been completed. Information was gathered from a variety of potential TDS users, and their concerns and interests have been incorporated into the system design where possible. The system used occupational survey (OS) data as a starting point to cluster tasks into Task Training Modules (TTMs) which were then used to describe jobs and training programs of an Air Force specialty and serve as the basis for collecting additional data. New data collection instruments were developed to gather information about where TTMs are trained, where they could be trained, training time, and other variables. Specialties were modeled, alternatives were defined, and managers' preferences among various utilization and training (U & T) patterns were collected for analysis. Training costs and resource requirements information were generated, including very comprehensive estimates of on-the-job training costs and capacities for representive field units. Comparisons were made among alternative U & T patterns in terms of total training costs and capacities which very clearly highlight the possible consequences of decisions by specialty managers and training decision makers. Overall, the proof-of-concept TDS gives such managers and decision makers a significantly enhanced capability to visualize and evaluate the results of their own decisions.

As in any significant R&D effort, some issues and problems were encountered during the development of the TDS. This chapter notes the issues, documents some of the alternative methodologies tested to overcome the problems encountered, and outlines potential future lines of research and development of the system.

4.1 General Issues

There are several general topics (involving more than one TDS subsystem) which warrant some discussion. Subsystem issues will be discussed in the following section

4.1.1 Subject-Matter Expert (SME) Involvement and Availability

The TDS project was designed to make extensive use of SMEs as primary sources of information and estimation of specialty data. This approach has been used very successfully in prior AFHRL research and development efforts such as the validation of the Weighted Airman Promotion System

(WAPS), occupational analysis research, task and occupational difficulty benchmarking (to set aptitude requirements), training emphasis research, strength and stamina requirements analysis, safety priorities determinations, and a number of other MPT projects.

Some of the most successful development activities in the TDS project were accomplished using this approach. For example, the initial task clustering effort was undertaken with AFS 811XX using a large panel (20+) of SMEs at a meeting at the Security Police Academy, Lackland AFB, Texas, in May 1985. This effort was made possible through the strong support of the functional manager (Air Force Office of Security Police, Kirtland AFB, New Mexico) who requested subordinate units, including the Security Police Academy, to provide SMEs for a 4-day session. Other data collecting efforts were integrated whenever possible with ongoing TPT and U & TW activities scheduled for other purposes; this greatly facilitated the development of needed TDS data bases.

TDY funds for SME participation in research projects are very limited both by budgetary constraints and by the difficulty in forecasting just <u>when</u> in an R&D project such participation will be necessary. In some cases involving very specialized or equipment-specific tasks, only a very small number of SMEs have the knowledge and experience required to make professional judgments or estimates; often such specialized individuals are fully involved in operational requirements and cannot easily be made available for R&D participation.

Consequently, there were instances where alternative approaches had to be used in the TDS development effort. TDS researchers also visited successive small groups of SMEs at their own bases or other research sites (AFHRL Detachment, Bergstrom AFB, TX). Extensive use was made of telephone contacts with training SMEs, particularly those in FTD units at widely dispersed operational bases. The AFHRL staff also assisted by performing some data collection trips to additional bases to secure needed RCS data. The research team then had to integrate the results of the various data gathering trips or contacts to approximate consensus results.

The occasional limitation of face-to-face SME interaction precluded use of desired techniques (such as full consensus ratings, SME validation of survey data summaries, and SME group estimation of the impact of changes on specialty jobs, training courses, and other programs). This kind of limitation can perhaps be solved by combining TCS, FUS, and RCS data collection efforts into one or two major meetings and securing full functional manager support (as was done with Security Police).

In an operational setting, SME availability might be assured through extensive MAJCOM and functional manager coordination and periodic meetings of U & TWs. In future R&D programs, however, sufficient TDY funds should be programmed to ensure that adequate numbers of representative SMEs are available, and full support obtained from HQ USAF and MAJCOM functional managers for the specialty or specialties involved.

4.1.2 <u>Assessing System Products--The Criterion Issue</u>

A major innovation in the TDS was the development of data collection methods, procedures, and software to generate estimates of specialty

training costs and capacities. Econometric modeling was blended with occupational analysis outcomes and new data collection or estimation techniques to examine training costs, including costs of OJT, at a greater level of detail than has ever been possible previously.

The various pieces of TDS serve their individual functions well and have been tested or validated against known data sources where possible. However, when these pieces are combined in the TDS to generate total training cost and capacity estimates, there are no hard criteria against which the validity of the totals can be assessed for most training states (and particularly OJT costs for particular jobs or mission organizations).

One approach to testing overall system operation is to check the validity of data against known sources, for at least some subset of information. Work is underway to check some job assignment flow and specialty attrition estimates against rates calculated from Uniform Airman Records (UAR) data at three points in time (at 24-month intervals). This approach is expensive in terms of custom programming and computer time but provides some validation of at least some segments of the TDS data base.

The limitations created by the lack of an overall criterion can be mitigated to some degree by extensive testing of the system using varying data estimates or run parameters. This work in being undertaken through the sensitivity analyses noted earlier. Such sensitivity analyses are aimed at determining the relative impact of various data sources. If the system is run with a quick and inexpensive estimate and results compared to those from a time-consuming, expensive estimate and there is no practically significant impact on the final output, then the quicker and less expensive estimate is to be preferred. Where the use of a more costly estimation procedure does make a difference, then it must be used for the system to operate properly, or further R&D must identify or develop a better (less expensive) way to collect the information.

4.1.3 Complexity of Specialty Models and the TDS

The proof-of-concept TDS is an extremely complex system, requiring a large variety of types of input data, including parameter specifications, existing data from established data sources, and new data collected from specialty SMEs in the field. The various subsystems are all unique, innovative sets of both procedures and software, designed specifically to systematically build a body of information and data files concerning a specialty to a much more complex level than has previously been accomplished. The outputs of these subsystems are then combined to serve the needs of Air Force decision makers who need concise, specific data summaries and comparisons.

As presently configured, the TDS is a complex system which must be operated by an individual or team with extensive background in both statistical modeling and Air Force operational information. This is to be expected to some degree with any experimental system designed to function in an R&D environment. As Air Force personnel become familiar with the TDS, operational simplifications can be found and implemented.

In another sense, the TDS is not complex enough. There are a number of areas where compromises had to be made. For example, U & T patterns had

to be simplified in order to communicate them easily, and not all training programs were included (if the number of participants was very small or the programs were used only irregularly). Some assumptions had to be made in order to formulate information in ways that facilitated its use in the mathematical simulation of incumbent job and training flows. Some arbitrary decisions were made in calculating student travel costs and other variables, since only representative bases are included in the model (as opposed to a census of every base utilizing the specialty).

For at least the first few years of TDS use, its operation needs to remain in the hands of trained system specialists. These should be individuals with a good background in ASCII CODAP operations, job typing and analysis, statistical modeling, econometrics, and decision theory, as well as data collection, data analysis, and report writing. It may be that a team of individuals extensively trained on the TDS will be needed, to ensure that all the requisite skills are available. At this proof-of-concept stage, attempts to operate the TDS using only the published reports and software documentation would be counterproductive.

Secondly, whenever the system is used, data outputs need to be checked carefully by analysts and by SMEs. Specialty SMEs need to be periodically asked to review models developed for their career field, as well as to review data outputs for realism and practicality. Such SMEs would need to be thoroughly briefed on the objectives and methodologies used in the TDS, and must be reassured that in the TDS, system outputs are still "research" products.

Thirdly, the ideal use and testing of the TDS would be to extend the use of the system to some additional deliberately chosen specialties where sequential U & TWs can be undertaken in parallel with the TDS study. This would provide for "real-world" testing of TDS data, products, and possible decision recommendations until the system is fully operational and implemented. Such parallel developments would also result in suggestions for improvements and further innovations which could make TDS more valuable to potential users.

4.1.4 <u>Currency of Specialty Data in TDS Files</u>

One issue raised by some HQ ATC Training Staff Officers (TSOs) participating in TDS progress reviews or in a special TSO briefing on the TDS Simulator in early 1987 was the question of who will maintain and update data files used in the TDS. There are changes occurring in most specialties constantly, some minor and some with significant implications for training. The TSOs were concerned that unless ongoing changes were monitored and their potential impact assessed, the TDS data base could quickly become obsolete, and therefore be of limited utility in training decision making. The implication of the TSO concern is that if specialty-specific data bases are developed, they must also be updated and, where necessary, new TDS data must be collected. This is necessary if TDS is to be useful to U & TWs, TPTs, and training staffing agents.

4.2 Subsystem Issues

4.2.1. TCS Issues

In the development and validation of the Task Clustering and TTM Allocation components of the TCS, several issues were encountered which require some discussion. Some of these involve the nature of tasks and TTMs and their relative merit as training decision aids.

4.2.1.1 Task Modules as Training Modules. Development of TTMs through the TDS task clustering procedure (co-performance clustering with naming and refinement by SMEs) worked well for the four specialties studied in this R&D; however, based on their analysis of a few Security and Law Enforcement (AFS 811XX) TTMs, some USAFOMC personnel indicated they would prefer that TTMs be retitled as simply "task modules." This would eliminate the inadvertent connotation that all tasks within a task cluster must always be trained together (in the same course block). Rather, in TDS most TTMs are expected to be trained to some degree of proficiency in several different training settings.

This is an important issue for TDS in terms of user understanding and use of the system. TTMs must have a general acceptance by the using community (trainers, managers, and field personnel) in order to effectively meet their purpose and properly function as a decision aid.

The suggestion to use the term task module (TM) rather than TTM is a very constructive idea which should be adopted. In the TDS, TTMs are used to describe both jobs and training programs; TM is more descriptive of such multiple uses.

4.2.1.2 PME Versus Technical Tasks. In all four TDS specialties, some SMEs involved in task clustering made a marked distinction between supervisory and management task groupings (which they considered the province of PME) and technical task clusters (which involve technical training or OJT). This clearcut dichotomy is consistent with the current Air Force philosophy regarding PME. Such a philosophy constrains AFS decision makers to accept this dichotomy, regardless of whether the needs of each AFS are properly serviced by standard Air Force PME programs. More than one participant at TDS progress reviews suggested that standard PME programs do not fully meet the needs of Communications/Electronics NCOs. The time-phasing and opportunity to attend standard PME courses do appear to differ among specialties. For the TDS, a standard set of PME TTMs may be required to service all specialties, or a better way needs to be developed to relate PME knowledges and skills to the tasks (TMs) of each specialty so as to identify AFS-unique requirements.

4.2.1.3 Principles or Prerequisite Knowledges. Current technical training programs often include instruction on basic principles which can be linked only indirectly to specialty tasks. Examples include electronics principles, introductory medical knowledge, basic mathematics skills, etc. It is difficult to account for such prerequisite knowledge training or to estimate the degree of required TTM proficiency attributable to such basic knowledges in the TDS model. This problem was addressed in the present TDS effort by identifying all TTMs which may

require, for example, electronics knowledge, and then attributing equal portions of the total course hours (from AFR 50-5) to those TTMs. Further R&D effort is needed, however, to develop better ways of accounting for knowledge fundamentals in the system. Separate knowledge TTMs may need to be constructed, or perhaps the AFS task list itself needs to be modified to include knowledge-specific basic tasks.

4.2.1.4 Weapon System Specific Tasks. In some specialties, such as Environmental Systems Maintenance (AFS 423X1), it was difficult to distinguish work on various aircraft systems, due to the generic task statements in the USAF Job Inventory. Such generic tasks may disguise system differences in task performance and thus, in OJT requirements. If this is so, then TDS would significantly underestimate the total training requirements and costs for the specialty. Further R&D is needed to assess when tasks should be more weapon-system-specific. Such an effort has significant implications for other AFHRL programs, including aptitude requirements (task difficulty), person-job match, and basic skills research and development.

4.2.1.5 Concept of Proficiency. Early in the TDS project, the question arose of how to address the level of proficiency required for each task or set of tasks (TTM). Specialty Training Standard (STS) proficiency codes appeared ill-suited for collecting quantitative estimates of required proficiency; some type of scaled values were needed. Secondly, STS codes have been a continuing source of controversy between the resident training community and OJT supervisors (who operate on a "go/no go" concept of task proficiency).

For the TDS, the OJT go/no go concept provided a good starting point for an operational definition of required proficiency. The "go" point represents the target level of performance for all training; if an individual reaches that point, the training requirement is satisfied. For TDS purposes, common scale values can be assigned by dealing in terms of the proportion of the required proficiency met in any training setting; that is, as a percentage. Thus, based on the go/no go OJT concept, TDS assesses the required proficiency on a TTM which is to be achieved through training. This conceptualization worked extremely well in the TDS project and SMEs quickly understood and used this operational definition in making training requirement estimates and allocations.

At some point in the future, however, this construct needs to be related to STS proficiency codes, and an equating or translation scheme devised. This is needed to properly utilize TDS data in U & TWs for STS reviews. In addition, further R&D is desirable to investigate advanced proficiency levels which go beyond basic proficiency requirements (i.e., advanced troubleshooting, highly skilled task performance, etc.), except where such advanced activities are represented in a separate task. This is an issue particularly relevant for higher skill and grade levels.

4.2.1.6 TTM Allocation Data. In the present TDS R&D, there was occasionally some inconsistency between information gathered in the TTM Allocation Survey and the data derived for the RCS. In some cases, training resource requirements or availability information was not

provided by the SMEs for some TTMs which other SMEs, responding to the Allocation Survey, indicated were trained. It is not clear if this was a data collection problem, if it was a sampling issue, or if one or the other set of SMEs simply misunderstood directions. In any case, data inconsistency is a problem which needs to be resolved. One solution would be to integrate the data collection for the TTM Allocation and the RCS surveys, using exactly the same sample of SMEs. Another possible alternative would be to have such discrepancies resolved to consensus in an SME panel session such as a TPT or U & TW.

4.2.2 FUS Issues

Several issues surfaced during the development of current and alternative AFS models for the TDS.

4.2.2.1 Missing Data on Training Courses. As noted earlier, some training courses were excluded from the TDS models of several AFSs. The types of courses omitted were those for which no data were available, where the course had no regular input (courses on standby), or courses where the number of students involved was extremely small. In the proof-of-concept TDS, such training requirements are automatically transformed into an OJT requirement and thus are accounted for in the system, because of the way OJT needs are computed. However, the allocation data for several specialties suggest that some relevant TTMs cannot be trained to complete proficiency through OJT alone. Thus, the simplified or abstracted model developed for such a specialty somewhat overstates the need for OJT and underestimates the requirement for formal classroom training. Although the degree of distortion is relatively small, this is a problem which needs to be examined through further R&D. If it is found to be a significant problem, then more complex AFS models may be necessary.

4.2.2.2 Additional Training Settings. In attempting to build a general methodology for modeling specialty jobs and training, some simplification of the possible training settings was necessary. Generally, the TDS deals with classroom, hands-on (field training), self-study (CDC, etc.), and OJT. Almost all Air Force training can be forced into these generic categories. However, such a simplified schema does not provide separate data for a number of other possible ways in which training can be delivered. Under the present schema, a computer-delivered training system (CDTS) or interactive video disk (IVD) in a unit learning center could be classified as either classroom training or as self-study. Specialty-unique training systems, such as some of those developed by Air Force Communications Command (AFCC) or the Security Police Educational Subject Block Indices (ESBIs), are well-developed systems and may need to be accounted for separately in the modeling of relevant specialties. For each additional training setting added to the model, additional ratings (allocations, resource requirements, resource availability, etc.) would have to be generated, further complicating an already complex system. It is not yet clear, based on work with just four specialties, whether this is really a problem or if the simplified training setting schema provides sufficient data for AFS decision makers. As the TDS is used with other specialties or when a specialty is examined

a second time, it may be necessary to expand the training settings considered in order to account for some additional training delivery options, even at the risk of making the AFS models more complex.

4.2.2.3 Steady-State Versus Variable Input Models. One of the simplifying assumptions made during development of software for the FUS was that of a constant input level. In the present FUS simulation program, the rate of input to a specialty is a specified value and the program builds up a specialty population over an extended time period until the value reaches an equilibrium which approximates the present population level. Only the data relating to this equilibrium period are relevant for analysis of specialty training and utilization programs. This kind of simplifying assumption was necessary in the development of the TDS to make it possible to produce the simulation model. However, examination of historical data from ATC production records and from the Occupational Research Data Bank (ORDB) at AFHRL strongly suggests that most specialties have varied considerably in input over the last 6 to 8 years. Indeed, there appear to be some general trends across time which should be reflected in any specialty model. For example, the input for AFS 423X1, Environmental Systems Maintenance, has decreased through the years as some bases convert to contract maintenance for such equipment (mostly ATC bases or for C-9 aircraft). In Security Police (AFS 811XX), there has been a gradual buildup in recent years (the TPR has increased from 5,000 to 7,000+) as ground launched cruise missiles (GLCMs) were deployed in Europe and the Space Command complex was activated; this trend was reversed when the Intermediate Range Missile treaty was signed at the 1988 Moscow summit. Such trends in two of the four specialties included in the present R&D are sufficient to indicate that variable input modeling is probably required so that the TDS can better approximate general trends. This will require some reprogramming to allow more complex simulations; this possibility should be considered for any follow-on TDS project.

4.2.2.4 Training Decay Functions. With good training, a person can achieve full proficiency in performing a group of tasks (TTM); however, unless the individual regularly performs the tasks, he or she will tend to lose that proficiency. The loss rate can be tested and displayed as a mathematical function--the training decay function (TDF). Such a function has obvious utility for TDS, in that it directly affects the amount of training required when an individual moves to a new job or is assigned new responsibilities. If a person no longer has full proficiency for the new tasks due to the passage of time since receiving training, or has not performed the tasks before, then additional training is necessary. In the TDS development effort, this problem was handled by assuming that if a TTM was performed in the previous job it did not need to be trained, but that if it was not performed in the previous job, it did need to be trained.

There is a good body of scientific literature on TDFs, but very little information is available on such functions as they relate to specific tasks or groups of related tasks (TTMs). There are a number of studies in progress on the value of prior experience and how knowledge of some subjects decays over time. As such information becomes available, the TDFs for relevant subject areas should be included in TDS modeling (if the subject areas can be directly related to TTMs). Specific R&D to identify

such functions for Air Force training areas and AFS-specific TTMs would be worthwhile.

4.2.3 RCS Issues

Several areas of the RCS included problems or issues which merit discussion.

4.2.3.1 Resource Requirements and Representative Sites. The identification of the amounts of resources required for training each TTM by each training setting became extremely complex and difficult. Generalized resource requirements surveys were used which listed all TTMs and the general types of resources expected to be involved; and SMEs were asked to estimate quantities, hours of student use, and additional resources. Trainers of specific TTC or FTD courses were also to indicate which resources were shared with other courses, with other specialties, or with operational users. The data collected indicated that some SMEs had difficulty dealing with such multiple taskings. In addition, data collected in this survey proved inconsistent with information developed in later Resource Availability surveys.

As noted earlier, some improvement in the quality of data is expected through improved instructions and changes in data collection procedures. However, it may be that a tailored approach to this kind of data collection is required. If representative sites can be identified early (perhaps in the initial task list development process), then the TTMs and resources at each base could be compiled into a separate booklet so that survey respondents at that base need deal only with relevant issues. This would necessitate a tailored booklet for each representative site but would greatly ease the time and effort required of SMEs.

4.2.3.2 Resource Availability. There was some disparity between information collected in the TCS Allocation Survey and that compiled later from the RCS Resource Availability questionnaire. Part of this problem may be due to confusion concerning the concept of "training time" as it is used in the TCS (hours spent training the tasks of a TTM) versus in the RCS (hours during which specified resources might be used for training).

A further anomaly involved disparities between the resource requirements and resource availability data. In some cases, equipment or supplies were indicated as required, yet none was shown as available (even though the training was being provided successfully). This kind of discrepancy limited the extent to which training capacity could be calculated for the test AFSs in this present project. Many non-labor resources had to be excluded from the calculations at this time, although the capability to produce such estimates does exist in the system. However, a better way to collect the information must be implemented, or at least some methodology must be developed which permits resolving inconsistencies between the various data sets.

As an interim solution, the collection of training allocation data, resource requirements information, and resource availability data should be linked; the three data sets should be gathered at the same time with the same set of SMEs. This will at least control for differences in

survey administration and ensure that a common set of definitions is used. One possible alternative is to have the data sets that are collected by survey reviewed by a panel of representative SMEs and any disparity resolved through face-to-face negotiation. This is how such problems would probably be handled in an operational system; i.e., through a training conference or U & TW.

4.2.3.3 RCS Parameters. In some cases, decisions had to be made as to how to calculate variable costs for items such as average TDY travel costs; salary costs of students and instructors (estimated from average grade levels); student-to-instructor ratios in classroom, FTD, and OJT programs; etc. Such decisions were embodied in separate data files or parameter specifications. This modular approach provides considerable flexibity for the TDS in that as such rates change or as better estimation procedures are developed, new values can be inserted into RCS data files without reengineering the system (for example, as TDY travel and per diem allowances change, one could revise that file and then calculate the impact of that change by running the data for a sample AFS). All of the parameters and estimation methods used in the present TDS are candidates for improvement. The programmed sensitivity analysis and T & E of the system will identify those parameters or estimation methods which should have priority for further development work.

4.2.4 IOS Issues

Some areas of needed improvement in IOS modeling activities were addressed earlier (under the FUS; see section 4.2.2). Other IOS issues involve the interface with users. At present, the IOS has separate interface requirements for modeling and optimization runs; an analyst or technician must set up each run separately and must create a format for reports. In any future TDS development, the IOS needs to be made more user-friendly with a menu system of TDS options, and a report generator should be developed to help users create products to meet their needs.

Until such user-friendly software can be developed, a trained TDS analyst will be needed to set up and run any type of modeling or optimization problem. The models and data files are sufficiently complex that an untrained user would have great difficulty in operating the system.

5. CONCLUSIONS AND RECOMMENDATIONS

The TDS has considerable potential value for a wide range of Air Force decision makers. It can help them to understand the current jobs and training programs of an Air Force specialty, to formulate plausible alternatives, and to test out the consequences of proposed changes. The capabilities which the TDS provides should be extremely useful to various levels of Air Force managers, ranging from the Air Staff to training managers at MAJCOMs, HQ ATC, and the Technical Training Centers. The system could be effectively employed to provide objective information and evaluation capabilities for Utilization and Training Workshops, Training Planning Teams, and other AFS-oriented decision making groups.

5.1 Conceptual Issues

5.1.1 A Systematic Approach

One of the major strengths of the TDS is the systematic approach used for development of objective data bases that serve as the foundation for reports or briefings to appropriate Air Force decision makers for their use in assessing the potential impact of various proposed changes on an Air Force specialty. The capability to project and assess the consequences of change has not been available in the past. Instead, decision makers had to make subjective judgments as to possible outcomes, based on very limited amounts of information. The TDS can provide substantially better information for use in such decisions.

The systematic approach to building Air Force specialty-specific data bases--and collecting additional relevant information about AFS jobs, training programs, training costs, and possible alternatives--represents a major improvement in Steps 1 and 2 of the ISD process (analyze system requirements and define training requirements; see AFR 50-8). Better definition of training requirements begins with an improved understanding of the work to be done and how the specialty is organized to accomplish such work.

5.1.2 Modeling an Air Force Specialty

Through interviews with various Air Force managers, staff officers, and trainers, it became obvious that everyone had some knowledge of various systems and programs, but typically no one person had a complete picture of all available training, nor all of the jobs, in an Air Force specialty. Thus decisions on changes to the specialty currently were being made, to some degree at least, on partial knowledge. A key improvement which could be made, therefore, is to provide a more complete picture of current specialty jobs and training.

TDS has focused on building a specialty model that can assist managers (and other users) in understanding the flow of people through initial skills training, initial jobs (including OJT and CDC completion), advanced training and jobs, PME and other supervisory and management training, and senior-level responsibilities and positions. The model must depict the multiple routes of entering the specialty, as well as the multiple exits (cross-training, separation, special assignment, retirement, etc.). The model must also accurately portray the various training programs and possible combinations of training which are available, as well as the complexity of possible job assignments. One of the most difficult issues is the accurate estimation of the probability of being reassigned from one type of job to another; these probabilities directly and immediately impact on the calculations of the total training requirements of a specialty. It is not sufficient for a model to merely list the available training programs and jobs. A useful TDS model must also portray the dynamics of the reassignment system in order to properly portray how advanced training and OJT requirements are generated and met in the USAF.

A very basic issue involved in creating such a model is the language used to designate the various jobs of a specialty and to communicate what

such jobs involve. To describe each position or job on a task-by-task basis becomes impossibly complex, since any specialty involves from several hundred to over a thousand possible tasks which an incumbent might be required to perform, and these tasks are grouped many different ways to form jobs. The clustering of AFS tasks into 50 to 100 modules (Task Modules) provides the necessary simplification so that the specialty can be modeled and understood. Naming the TMs in a way that they can be adequately communicated (among individuals at various organizational levels and in different functions) is a key issue. If properly named by experienced SMEs, the set of TMs serves as an excellent tool for assuring full understanding of specialty training requirements and personnel utilization policies.

Creating sets of TMs and modeling the jobs of specialties were accomplished quite successfully in the TDS. Some problems were encountered in dealing with rapidly changing conditions. In the Electronic Computer and Switching Systems specialty, AFS 305X4, for example, some of the jobs were being transferred to other specialties; new shredouts were being created; and training programs were in transition. Another problem was encountered regarding proposals to merge various specialties at advanced skill levels in order to develop broader technical skills (RIVET WORKFORCE). If only one specialty of the pair to be merged was studied in TDS (as happened with two specialties), then equivalent information was not available for the other AFS involved. This suggests that the TDS needs to be expanded to deal with multiple career ladders (Mitchell et al., 1987, section 5.1, page 110).

5.1.3 Single Versus Multiple Specialty Models

If major training decisions are to be made by multi-specialty functional community conferences (such as RIVET WORKFORCE), then the capability of the TDS should be expanded to properly service that need. In such cases, the models to be developed would be for multiple related specialties (functional areas), rather than for only one specialty. This probably represents a new order of complexity. Work on the present TDS with the Security Police involved two closely related specialties (Security, Law Enforcement) plus an additional shredout (Military Working Dog), and TDS was adapted to model these fields (while tracking the separate flows). In this case, the task list (OSR) contained all three subareas. For multiple specialties with separate task lists, some type of equating procedure would have to be developed, or a new OA would have to be initiated with a common task inventory.

The above discussion highlights an existing dichotomy in the Air Force training decision making process. AFS-specific decisions can be made in a U & TW, but multi-AFS decisions (which have very significant training implications) are made through functional conferences. Such different decision making mechanisms could probably be merged, by using the U & TW process to staff and implement major structural changes suggested by a functional conference.

5.1.4 TDS Versus Task Analysis

Another philosophical issue involves ISD techniques and technology. As noted earlier (Section 2.3.1), some individuals and organizations

interpret the ISD procedures as requiring that a complete task analysis of every technical task in the specialty be done <u>before</u> any decision can be made as to the training requirement (i.e., appropriate place and media for training delivery). The basic philosophy underlying TDS, however, is that many training decisions can and should be made concerning how the specialty is to be organized, the appropriate phasing of the delivery of training (i.e., when in an airman's career), and how tasks can be grouped for training, before any detailed task analysis is done. Such detailed task analysis can be an extensive, time-consuming process which is labor-intensive and highly variable in quality of output (Eschenbrenner, DeVries, Miller, & Ruck, 1980). The implicit TDS philosophy is to provide support for utilization and training decision making in the TPT, U & TW, or normal staffing process, and reserve detailed task analysis until after some of the critical decisions have been made.

Air Force guidance for training decision making needs to clearly specify the preferred procedure for ISD. The recent revision of AFR 50-8, Policy and Guidance for Instructional Systems Development (6 August 1984), established the TPT process as the major vehicle for implementing Air Staff program management documents (PMDs) and for defining training requirements for new weapon systems. A draft AFR 50-23, if approved, will enhance the role of U & TWs in making specialty-specific training decisions. This training decision philosophy is consistent with the type of approach taken in developing the TDS. Perhaps what is now needed is to revise other ISD documents, such as AFM 50-2 (25 May 1979) and AFP 50-58 (15 July 1978), to reflect the new training decision philosophy and current Air Force decision mechanisms. Both the U & TW and the TPT mechanisms for considering and executing needed training changes were developed after AFM 50-2 and AFP 50-58 were published; thus, a revision of both documents to update their guidance appears necessary.

5.2 TDS Responsibilities

One of the major mechanisms available for implementing the TDS as an operational system is a new Air Force Regulation. Such a regulation would authorize the establishment and continued operation of the TDS and delegate appropriate responsibilities to the various Air Force agencies involved.

A proposed draft regulation is included as an appendix to this report. In recommending responsibilities for various agencies in the establishment and operation of the system, this draft regulation follows recommendations made in the TDS Transition Plan (Vaughan et al., 1985).

The draft regulation embodies current training decision philosophy of the ISD process as defined in AFR 50-8, Policy and Guidance for Instructional Systems Development (ISD), 6 August 1984. In form and approach, the draft parallels AFR 35-2, Occupational Analysis, 23 July 1982. Since the emphasis here is to develop and provide training decision support services which are related to but different from the ISD and OA processes, it is appropriate that TDS should be covered by a separate regulation.

5.3 Recommendations

5.3.1 An Operational TDS

TDS should be transitioned into an operational system through approval of the draft Air Force Regulation included as Appendix A. Although there is still some work to be done to have a fully user-friendly, automated decision support system, TDS is now sufficiently developed to be of value to U & TWs, TPTs, and other Air Force training decision conferences.

5.3.2 Further TDS Testing

The present TDS was developed based on information collected on four Air Force specialties; the data varied in quality and utility. TDS should be extended by employing the present techniques and software with 4 to 8 additional specialties. This would serve to test the generalizability of the system to other types of specialties, as well as to identify any problems in procedures and approach not yet detected. Such an extension of the TDS R&D would be extremely valuable, and could be conducted by AFHRL in parallel with the operational implementation of the system by the USAFOMC. Close coordination of these efforts will be needed.

5.3.3 Additional TDS Research

A number of further research areas have been identified throughout the TDS project and were reported in the TDS Transition Plan (Vaughan et al., 1985), Information Gathering report (Mitchell et al., 1987), subsystem final reports, and earlier sections of this document. These areas range from basic research (training decay function variations by type of task or AFS, knowledge and skill requirements associated with groups of tasks in an AFS, etc.) to complex technological issues (generic or AFS-specific PME TTMs, techniques for identification of representative sites, etc.). Further R&D is needed to adapt TDS to handle multiple specialties and for use in the new weapon systems acquisition process.

The TDS development effort has successfully demonstrated that such a system is practical and has high potential utility. At the same time, the TDS was designed such that improved data can be substituted without having to reengineer the system. This approach ensures that TDS can evolve as new R&D projects or operational agencies make improved data available.

REFERENCES

Air Force Regulation 8-13 (1980, 12 June). Air Force training standards. Washington, DC: Headquarters, United States Air Force.

Air Force Regulation 35-2 (1982, 23 July). Occupational analysis. Washington, DC: Headquarters, United States Air Force.

Air Force Regulation 39-1 (1981, 30 April). Airman classification regulation. Washington, DC: Headquarters, United States Air Force.

Air Force Regulation 50-5 (1986, 1 June). USAF formal schools. Washington, DC: Headquarters, United States Air Force.

Air Force Regulation 50-8 (1984, 6 August). Policy & guidance for instructional systems development. Washington, DC: Headquarters, United States Air Force.

Air Force Regulation 50-23 (1982, 30 September). On-the-Job Training. Washington, DC: Headquarters, United States Air Force. (Also draft Revision, 1988).

Air Force Manual 50-2 (1979, 25 May). Instructional systems development. Washington, DC: Headquarters, United States Air Force.

Air Force Pamphlet 50-58 (1978, 15 July). Handbook for designers of instructional systems. Washington, DC: Headquarters, United States Air Force.

Air Training Command Regulation 52-15 (1982, 24 September). Career field utilization and training workshops (U&TW). Randolph AFB, TX: Headquarters, Air Training Command.

Air Training Command Regulation 52-22 (1981, 16 October). Occupational analysis program (corrected copy). Randolph AFB, TX: Headquarters, Air Training Command.

Archer, W.B. (1966). Computation of group job descriptions from occupational survey data (PRL-TR-66-12, AD-653 543). Lackland AFB, TX: Personnel Research Laboratory.

Christal, R.E. (1974). The United States Air Force occupational research project (AFHRL-TR-73-75, AD-774 574). Lackland AFB, TX: Occupational Research Division, Air Force Human Resources Laboratory.

Christal, R.E., & Weissmuller, J.J. (1988). Job-task inventory analysis. In S. Gael (Ed), Job analysis handbook for business, industry, and government. New York: John Wiley and Sons, Inc. (Chapter 9.3).

Datko, L.M., Cassidy, M.J., & Ruck, H.W. (1982, September). Standardized Position Oriented Training System (SPOTS): Task listing generation procedures (AFHRL-TP-82-16, AD-A120 119). Brooks AFB, TX: Manpower and Personnel Division, Air Force Human Resources Laboratory.

DeVries, P.B. Jr., Eschenbrenner, A.J., Jr., & Ruck, H.W. (1980, July). Task analysis handbook (AFHRL-TR-79-45[II], AD-A087 711). Brooks AFB, TX: Manpower and Personnel Division, Air Force Human Resources Laboratory.

Driskill, W.E., & Mitchell, J.L. (1979, October). Variance within occupations; jobs analysis versus occupational analysis. Proceedings of the 21st Annual Conference of the Military Testing Association. San Diego, CA: Navy Personnel Research and Development Center.

Eisele, C.R., Bell, T.R., & Laidlaw, C.D. (1978, December). Cost analysis of Air Force on-the-job training: Development and demonstration of a methodology (AFHRL-TR-78-88, AD-A069 791). Lowry AFB, CO: Technical Training Division, Air Force Human Resources Laboratory.

Eschenbrenner, A.J., Jr., DeVries, P.B., Jr., Miller, J.T., & Ruck, H.W. (1980, July). Methods for collecting and analyzing task analysis data (AFHRL-TR-79-45 [I], AD-A087 710). Brooks AFB, TX: Manpower and Personnel Division, Air Force Human Resources Laboratory.

Mitchell, J.L. (1988). History of job analysis in military organizations. In S. Gael (Ed), Job analysis handbook for business, industry, and government. New York: John Wiley and Sons, Inc. (Chapter 1.3).

Mitchell, J.L., Ruck, H.W., & Driskill, W.E. (1988). Task-based training program development. In S. Gael (Ed), Job analysis handbook for business, industry, and government. New York: John Wiley and Sons, Inc. (Chapter 3.2).

Mitchell, J.L., Sturdevant, W.A., Vaughan, D.S., & Rueter, F.H. (1987). Training decisions system: Information gathering technical paper (Draft Report, CDRL 23). Brooks AFB, TX: Prepared for the Training Systems Division, Air Force Human Resources Laboratory.

Mitchell, J.L., Vaughan, D.S., Yadrick, R.M., & Collins, D.L. (1987). New methods for portraying dynamic training and job patterns within Air Force specialties. Proceedings of the Sixth International Occupational Analysts' Workshop. San Antonio, TX: USAF Occupational Measurement Center.

Mitchell, J.L., Vaughan, D.S., Yadrick, R.M., Collins, D.L., & Hernandez, J.M. (1988). The Air Force training decisions system: Modeling job and training flows (AFHRL-TP-88-12, AD-A198 850). Brooks AFB, TX: Training Systems Division, Air Force Human Resources Laboratory.

Morsh, J.E. (1964). Job analysis in the United States Air Force. Personnel Psychology, 17, 7-17.

Perrin, B.M., Vaughan, D.S., Yadrick, R.M., Mitchell, J.L., & Knight, J.R. (1986, February). Development of task clustering procedures. Unpublished manuscript.

Perrin, B.M., Knight, J.R., Mitchell, J.L., Vaughan, D.S., & Yadrick, R.M. (1988, September). Training decisions system: Development of the task characteristics subsystem (AFHRL-TR-88-15, AD-A199 094). Brooks AFB, TX: Training Systems Division, Air Force Human Resources Laboratory.

Phalen, W.J., Staley, M.R., & Mitchell, J.L. (1987). New ASCII CODAP programs and products for interpreting hierarchical and nonhierarchical task clusters. Proceedings of the Sixth International Occupational Analysts' Workshop. San Antonio, TX: USAF Occupational Measurement Center.

Ruck, H.W. (1982, February). Research and development of a training decisions system. Proceedings of the Society for Applied Learning Technology. Orlando, FL.

Ruck, H.W., & Birdlebough, M.W. (1977). An innovation in identifying Air Force quantitative training requirements. Proceedings of the 19th Annual Conference of the Military Testing Association. San Antonio, TX: Air Force Human Resources Laboratory and the USAF Occupational Measurement Center.

Ruck, H.W., & Mitchell, J.L. (1987, April). Integration of training R&D into the USAF MPT system. Paper presented at the Second Annual Midyear Conference of the Society of Industrial and Organizational Psychology, Atlanta, GA.

Ruck, H.W., Thompson, N.A., & Stacy, W.J. (1987). Task training emphasis for determining training priority (AFHRL-TP-86-65, AD-A184 172). Brooks AFB, TX: Manpower and Personnel Division, Air Force Human Resources Laboratory.

Ruck, H.W., Thompson, N.A., & Thomson, D.C. (1978, October-November). The collection and prediction of training emphasis ratings for curriculum development. Proceedings of the 20th Annual Conference of the Military Testing Association. Oklahoma City, OK: U.S. Coast Guard Institute.

Rueter, F.H., Bell, T.R., & Malloy, E.V. (1980, October). Capacity of Air Force operational units to conduct on-the-job training: Development of estimation methodology (AFHRL-TR-80-46, AD-A091 228). Lowry AFB, CO: Logistics and Technical Training Division, Air Force Human Resources Laboratory.

Rueter, F.H., Vaughan, D.S., & Feldsott, S.I. (1987). The resource/cost subsystem (RCS) of the training decisions system (TDS): Project design. Unpublished manuscript.

Rueter, F.H., Feldsott, S.I., & Vaughan, D.S. (1989). Training decisions systems: Development of the resource cost subsystem (AFHRL-TR-88-52). Brooks AFB, TX: Training Systems Division, Air Force Human Resources Laboratory.

Shartle, C.L. (1959). Occupational information (3d ed.). Englewood Cliffs, NJ: Prentice Hall, Inc.

Stacy, W.J., Thompson, N.A., & Thomson, D.C. (1977, October). Occupational task factors for instructional systems development. Proceedings of the 19th Annual Conference of the Military Testing Association. San Antonio, TX: Air Force Human Resources Laboratory and the USAF Occupational Measurement Center.

Thompson, N.A., & Ruck, H.W. (1984, April). Safety training priorities (AFHRL-TR-83-57, AD-A141 711). Brooks AFB, TX: Manpower and Personnel Division, Air Force Human Resources Laboratory.

Vaughan, D.S. (1978, October-November). Two applications of occupational survey data in making training decisions. Proceedings of the 20th Annual Conference of the Military Testing Association (Vol. 1). Oklahoma City, OK: U.S. Coast Guard Institute (214-215).

Vaughan, D.S., Mitchell, J.L., Marshall, G.A., Feldsott, S.I., & Rueter, F.H. (1988, August). Training decisions system procedural guide: TDS user instructions. Unpublished manuscript.

Vaughan, D.S., Yadrick, R.M., Perrin, B.M., Cooley, P.C., Dunteman, G.H., Clark, B.L., & Rueter, F.H. (1984, August). Training decisions system preliminary design. Unpublished manuscript.

Vaughan, D.S., Yadrick, R.M., Perrin, B.M., Mitchell, J.L., Sturdevant, W.S., Rueter, F.H., & Ward, J., Jr. (1985, September). Training decisions system transition plan. Unpublished manuscript.

Yadrick, R.M., Knight, J.R., Mitchell, J.L., Vaughan, D.S., & Perrin, B.M. (1987, October). Field utilization subsystem administrative report. Unpublished manuscript.

Yadrick, R.M., Knight, J.R., Mitchell, J.L., Vaughan, D.S., & Perrin, B.M. (1988, July). Training decisions system: Development of the field utilization subsystem (AFHRL-TR-88-7, AD-A198 087). Brooks AFB, TX: Training Systems Division, Air Force Human Resources Laboratory.

Ward, J.H., Jr. (1963). Hierarchical grouping to optimize an objective function. Journal of the American Statistical Association, 58, 236-244.

ACRONYMS AND ABBREVIATIONS

ABGD	Air Base Ground Defense
ABR	Prefix for Airman Basic Resident Courses
AF	Air Force (used synonymously with USAF)
AFB	Air Force Base
AFCC	Air Force Communications Command
AF/DPPP	Force Programs, DCS Personnel, HQ USAF (formerly MPPP)
AF/DPPE	Training Programs, DCS Personnel (formerly MPPT & DPPT)
AFHRL	Air Force Human Resources Laboratory (see also HRL)
AFHRL/ID	Training Systems Division
AFHRL/MO	Manpower & Personnel Research Division
AFHRL/SC	Information Sciences Division (formerly the Technical Services Division)
AF/LE	DCS Logistics & Engineering, HQ USAF
AFM	Air Force Manual
AFMEA	Air Force Managment Engineering Agency
AFMPC	Air Force Military Personnel Center
AFOSP	Air Force Office of Security Police
AFP	Air Force Pamphlet
AFR	Air Force Regulation
AFS	Air Force Specialty
AOTS	Advanced On-the-job Training System
ASCII CODAP	Advanced CODAP system
ATC	Air Training Command
ATC/AC	DCS Comptroller, HQ ATC
ATC/ACMQ	Cost & Management Analysis, DCS Comptroller
ATCR	Air Training Command Regulation
ATC/TT	DCS Technical Training, HQ ATC
BLTMS	Base Level Training Management System
BMT	Basic Military Training
CDC	Career Development Course
CDTS	Computer-Delivered Training System
CEC	Cost Estimation Component of the RCS
CODAP	Comprehensive Occupational Data Analysis Programs
CONVERT	CODAP program to transpose case data files
CUT	Cross-Utilization Training
DCS	Deputy Chief of Staff
DIAGRAM	CODAP program for displaying structure of groups
DOD	Department of Defense
DRU	Direct Reporting Unit
EHF	Entity History File in UTPSIM
ENTRYS	Number of people entering jobs or training matrix in the UTPSIM process of the FUS
ESBI	Education Subject Block Index
FRMJOB	Probabilities of entities exiting jobs in UTPSIM
FTD	Field Training Detachment
FUS	Field Utilization Subsystem

GLCM	Ground Launched Cruise Missile
GMT	General Military Training
GROUP	CODAP program to organize hierarchical clusters
GRPREL	Inter-rater agreement programs in ASCII CODAP (REXALL in Fieldata CODAP)
HISCRN	History Screening program in UTPSIM
HQ	Headquarters
HRL	Human Resources Laboratory (also AFHRL)
HRM	Human Resources Management
IOS	Integration & Optimization Subsystem
ISD	Instructional Systems Development
IVD	Interactive Video Disk
JOBIDS	Titles and job identification file in UTPSIM
JOBTRN	Job-driven training probabilities file in UTPSIM
JOBTIM	Percent performing TIMs per job file in UTPSIM
MAC	Military Airlift Command
MADAR	Malfunction Automatic Detection, Analysis and Repair (AFS 328X4 system)
MAJCOM	Major Command
MODULE	Modular programs in ASCII CODAP
MODSET	Create Module Factor Set program in ASCII CODAP
MPPT	Training, Personnel Plans, HQ USAF (now DPPE)
MPT	Manpower, Personnel, & Training
MTS	Military Training Standard
MTT	Mobile Training Team
NCO	Noncommissioned Officer
OA	Occupational Analysis
OLD	Occupational Learning Difficulty
OJT	On-the-Job Training
OMT	Training Development Service of the USAFOMC
OPR	Office of Primary Responsibility
ORDB	Occupational Research Data Bank
OS	Occupational Survey
OSD	Office of the Secretary of Defense
OSR	Occupational Survey Report
OUTEHF	Output Entity History file from UTPSIM which contains the job and formal training history of each individual (entity)
OVRLAP	CODAP program to compute coperformance of tasks
PJM	Person-Job Match
PMD	Program Management Directive
PME	Professional Military Education
PMP	Program Management Plan
PMS	Pipeline Management System
POI	Plan of Instruction
POM	Program Objective Memorandum
PPBS	Planning, Programming & Budgeting System
PRTMOD	Print Modular Factor program in ASCII CODAP

PTT	Program of Technical Training
RCS	Resource/Cost Subsystem
R&D	Research and Development
RPR	Request for Personnel Research
RRC	Resource Requirements Component of the RCS
RUNPAR	Run Parameter File program of the FUS
SLAM	Simulation program tested for the FUS
SME	Subject-Matter Expert
SOA	Separate Operating Agency
SOW	Statement of Work
SP	Security Police
STS	Specialty Training Standard
TCC	Training Capacity Component of the RCS
TCS	Task Characteristics Subsystem
TD	Task Difficulty
TDF	Training Decay Function
TDP	Training Development Plan
TDS	Training Decisions System
TDY	Temporary Duty
TE	Training Emphasis
T&E	Test and Evaluation
TIES	Task Identification and Evaluation System
TIMTRN	TAFMS-driven Training probabilities in UTPSIM
TJBTRN	Job and TAFMS Training matrix in UTPSIM
TM	Task Module (new term for Task Training Module)
TOJOBS	Probability matrix for entering AFS jobs, UTPSIM
TPR	Trained Personnel Requirements
TPT	Training Planning Team
TRNPAR	Training Parameters file in the UTPSIM of the FUS
TRNPRF	Training Proficiency program in UTPSIM used to calculate OJT requirements.
TSO	Training Staff Officer
TT	Technical Training
TTC	Technical Training Center
TTM	Task Training Module
UAR	Uniform Airman Record
U&T	Utilization and Training
U&TW	Utilization and Training Workshop
USAF	United States Air Force
USAFOMC	USAF Occupational Measurement Center (ATC)
USAFOMC/OMD	Occupational Test Development Division
USAFOMC/OMT	Specialized Skills Training Division (also called the Training Development Service)
USAFOMC/OMY	Occupational Analysis Division
UTPSIM	U&T Pattern Simulation Program in the FUS
XPOSE	CODAP program to transpose case data files

APPENDIX A: DRAFT AIR FORCE REGULATION FOR TDS

DEPARTMENT OF THE AIR FORCE | DRAFT | AF REGULATION 50-XX
Headquarters US Air Force
Washington DC 20330

---date-----

Training

POLICY AND GUIDANCE FOR THE TRAINING DECISIONS SYSTEM

This regulation authorizes the Air Force Training Decisions System (TDS), outlines its functions, and delegates responsibilities for its operation and maintenance. The TDS provides necessary objective data and decision support services for Air Force activities involved in making major training decisions. Supplements must have prior approval (AFR 5-13).

1. TDS Explained. The Air Force TDS is a computer-based, decision support system which provides services to assist Air Force training decision making agencies or conferences in analyzing AF Specialty (AFS) or new weapons system operations and defining AFS education and training requirements (Steps 1 and 2 of the ISD process; see AFR 50-8). The objective of the TDS is to collect empirical data concerning personnel utilization and training patterns, associated training requirements, and costs of training for a specialty (or group of specialties), and to analyze, process, and summarize such data into forms useful to AF training decisionmakers. Using TDS data, plans or guidance on expected changes in an AFS, and relevant input from other AF agencies, decisionmaking bodies such as multicommand Utilization and Training Workshops (U&TWs), Training Planning Teams (TPTs) and other training decision conferences will optimize their decisions in terms of training relevance, practicality, and costs.

NOTE: Other elements of the ISD process are outlined in AFR 50-8, AFMs 50-2 and 50-62, and AFP 50-58. Interservice Procedures for ISD may be used in lieu of or in addition to AFP 50-58.

New Regulation
No. of Printed Pages: 3
OPR: DPPTS (LTC J. Jasper)
Approved by: LtGen T. Hickey
Writer-Editor: __________
Distribution: F

2. HOW TDS IS TO BE USED:

a. In support of U&TWs, TPTs and other AFS training decision meetings, the TDS will:

(1) Describe the AFS in terms of the groups of tasks which could or should be trained together (Task Modules or TMs) using the relevant occupational analysis (see AFR 35-2) as a starting point, and analyze the characteristics of AFS tasks or TMs, the way in which the work of the AFS is organized (i.e., the jobs which are performed), specialty training programs (in terms of tasks or TMs), and the dynamic flow of people through both jobs and training programs over the span of their careers. This qualitative description of the AFS provides the specialty overview and serves as the baseline for managment decisions concerning AFS training.

(2) Collect quantitative data concerning how training is and might be allocated to various training settings (classroom, self-study, field training, on-the-job training, etc.), and develop statistical functions to relate hours of training to required proficiency for each setting.

(3) Estimate transition probabilities among various training programs and jobs for successive assignments so as to model, in quantitative terms, the utilization and training pattern describing the AFS, outlined in (1) above.

(4) Develop realistic alternative patterns or AFS models, based on programmed or desired AFS changes, to provide a basis for comparative evaluation among possible choices which the U&TW or other AFS training decision agency might recommend.

(5) Develop data bases reflecting manpower, resources, and annual recurring costs of required training based on actual data from representative sites and training programs, with predictions of total requirements for the current and alternative AFS models being examined, to provide the basis for evaluating the relative merit of each alternative.

(6) Provide statistical analysis services including optimization routines and summary reports as directed by the U&TW or other AFS training decision body to assist in their evaluation and decision processes.

(7) Maintain and update TDS data bases for an AFS, as directed by the U&TW or other AFS training decision body for the lifecycle of the training review process.

b. U&TWs and other AFS training decision meetings will use the TDS to:

(1) Formulate a description of the specialty or specialties as a basis for analysis of AFS training requirements.

(2) Examine alternative job structures (utilization and training patterns) based on known or desired changes in the AFS.

(3) Evaluate the manpower, resources, and cost implications of the various alternatives.

(4) Recommend adoption of the AFS Utilization and Training pattern which optimizes AFS training in terms of managers' preferences or total training costs.

(5) Formulate an action plan to implement the selected training options.

3. HQ USAF RESPONSIBILITIES:

a. General:

(1) Promote the use of TDS services by U&TWs and other training decisionmaking agencies.

(2) Coordinate actions relevant to the TDS among HQ USAF, MAJCOM, SOA, and DRU offices of primary and collateral training responsibility.

(3) Provide staff assistance to TDS analysts collecting information on functional developments and plans as they impact specific AFSs and AFS training programs, and provide preferences among alternative U&T patterns for TDS and U&TW analysis.

b. HQ USAF/DPPT will use TDS services in planning and executing the management of Air Force training programs. Specifically, HQ USAF/DPPT has responsibility to:

(1) Establish Air Force policy for the creation, operation, and maintenance of the TDS.

(2) Monitor the use of TDS services throughout the Air Force.

(3) Review and approve U&TW action plans to insure that appropriate uses of TDS services have been made.

(4) Provide for the continued development and refinement of the TDS through sponsorship of appropriate Requests for Personnel Research (RPRs) and associated funding priority via the Planning, Programming, and Budgeting System (PPBS).

4. MAJCOM, SOA, and DRU Responsibilities:

a. Functional Managers will:

(1) Participate in U&TWs and other training decision meetings using TDS data to support critical training decisions for relevant AFSs.

(2) Coordinate and support visit requests of TDS analysts (AFHRL, USAFOMC, or contractors) to Headquarters or operational units to collect training data, as needed.

(3) Coordinate and support requests of TDS analysts for resource, manpower, and cost data for training programs within the command.

(4) Provide AFS subject matter experts (SMEs) from subordinate representative units for TDS data collection and validation meetings, as required.

(5) Review and staff completed TDS studies and U&TWs for relevant AFSs to assess potential impact on MAJCOM, SOA, or DRU operations.

b. ATC Additional Responsibilities:

(1) Prepare Air Force numbered TDS publications and amend the ISD literature to include TDS as directed by HQ USAF/DPPT.

(2) Serve as the Air Force clearinghouse for TDS information and support other MAJCOMS, SOAs, and DRUs in obtaining TDS related data.

(3) Develop and maintain guidance for the use of TDS services by chairpersons of U&TWs.

(4) Provide guidance, direction, and staff surveilance for the operation of the TDS.

(5) Program for required manpower and funds to establish and maintain the TDS within the USAFOMC.

(6) Provide internal coordination of U&TWs with staff and subordinate units to assess the impact of such plans on relevant training documents and plans.

(7) Provide access of TDS analysts to HQ ATC cost analysis and training resources databases for collection of AFS training cost data.

(8) Provide access for TDS analysts to the PMS database for AFS training input, attrition, and production figures (current and historical).

(9) Coordinate with AFHRL to define and support RPRs for the further development of the system.

c. USAFOMC Responsibilities:

(1) Establish the TDS as an operational capability through installation of TDS software on the USAFOMC computer, and maintain a hardline interface with the AFHRL computer to provide access to the TDS, CODAP, and other support software or files. The system shall, at a minimum, have the capabilities outlined in paragraph 2. above.

(2) Designate and train selected analysts to serve as TDS specialists responsible for conducting TDS projects.

(3) Solicit and consider candidate AFSs for TDS studies, and submit such candidates for prioritization along with occupational analysis and training development projects.

(4) Schedule approved TDS studies in an appropriate section of the USAF PTT, Part 2.

(5) Program and budget for travel by analysts in support of priority TDS projects and coordinate such travel with relevant organizational units. Direct communication with AF units is authorized, with information copy to relevant MAJCOM, SOA, or DRU Headquarters training or functional staff.

(6) Convene meetings and AFS panels as required to develop, review, or validate TDS data files and major findings.

(7) Prepare a report of each study for submission to the U&TW or other training decision making meeting and, with the approval of the U&TW, for publication.

(8) Maintain and update TDS studies and data files as needed.

(9) Coordinate with AFHRL on the maintenance and further development of the TDS, to insure that TDS software and procedures are refined to resolve any problems encountered in the operational use of TDS.

d. AFHRL Responsibilities:

(1) Serve as the focal point for further TDS research and development; maintain and refine TDS software and procedures on the basis of user feedback.

(2) Participate in a representative sample of Air Force U&TW conferences to assess the need and form of future TDS R&D needs.

(3) Develop R&D projects to improve the system and enhance its utility to the Air Force.

(4) Provide representation to serve on TDS project priority

review panels and coordinate on AFHRL assistance needed for such projects.

(5) Provide coordination with ASCII CODAP development to insure the systems remain compatible so as to facilitate and optimize the use of CODAP data in TDS projects.

(6) Conduct research to automate the flow of information between TDS users and additional potential users (Manpower, Personnel, and Training data systems).

(7) Coordinate research efforts to maximize the cross utilization of R&D results among developing MPT systems.

BY ORDER OF THE SECRETARY OF THE AIR FORCE

OFFICIAL

LARRY D. WELCH, General, USAF
Chief of Staff

JAMES H. DELANEY, Colonel, USAF
Director of Administration

☆ U.S. GOVERNMENT PRINTING OFFICE: 1989—661-041/000